Nordic Energy Research

Toolbox for a Secure Energy Supply

Capacity Mechanisms and Non-Fossil Flexibility Support Schemes

Contents

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FOREWORD

At Nordic Energy Research, we are proud to support the Nordic countries in building an energy system that is not only sustainable but also secure and resilient. This work directly contributes to the Nordic Council of Ministers' vision that *the Nordic region will become the most sustainable and integrated region in the world by 2030*.

Recent geopolitical developments have sharpened the focus on energy security and the need for generation adequacy. As we accelerate the green transition, it is essential that we also strengthen the mechanisms that ensure reliable supply—even in times of stress or uncertainty.

This report offers a practical toolbox of solutions to help policymakers address evolving challenges. By combining insights from existing capacity and flexibility support schemes in Europe and beyond with a regional Nordic perspective, we aim to equip decision-makers with the knowledge needed to act both effectively and collectively.

Klaus Skytte
CEO, Nordic Energy Research


↑ Photos: iStock and Unsplash

1. EXECUTIVE SUMMARY

1.1 Introduction

This report was commissioned by Electricity Market Group (EMG), a working group under the Nordic Council of Ministers. The objective is to support Nordic governments in designing effective and efficient Capacity Remuneration Mechanisms (CRM) (also referred to as Capacity Mechanisms), and/or Non-Fossil Flexibility Support Schemes (NFFSS) to ensure security of supply within a rapidly changing electricity market landscape. Addressing increasing concerns about maintaining adequate firm capacity and flexibility amid the green transition, the report evaluates various designs, both existing and new, assessing their effectiveness, cost-efficiency, and compatibility with existing market structures.

The report presents suitable market mechanisms tailored to various future scenarios in the Nordic region, offering a flexible toolbox rather than endorsing a single solution. It assesses each of the designs and evaluates their effectiveness in addressing different scenario combinations, including cold winters, interconnection failures, major supply disruptions, and extended periods of low renewable energy generation ('dunkelflaute'). Furthermore, it examines cross-border participation and the harmonisation of markets across the Nordic region.

While this report evaluates various designs for maintaining adequate firm capacity and flexibility, Nordic decision-makers should also prioritise assessing the alternative: supporting the functioning of the energy-only market to alleviate the need to intervene. They should examine existing recommendations for electricity market reform to optimise market efficiency and ensure security of supply. Market intervention should be considered only as a last resort, given the substantial financial implications of capacity mechanisms. According to ACER, annual capacity payments for market-wide CRMs in Europe range from approximately €20,000 to €60,000 per MW. Applying this to the Nordic region as a rough estimate, covering the 2023 peak demand of ~65 GW would require annual payments of €1.3–3.9 billion. Irrespective of any decision on support mechanisms for capacity and/or flexibility; enhancing the functioning of the energy market to deal with scarcity would likely be a 'no-regret' option.

1.2 Main design recommendations

1.2.1 Dispatchable flexible reserve

Recommended implementation: The dispatchable flexible reserve mechanism is particularly suited to addressing low-probability, high-impact events that require relatively rapid, yet planned responses. This design incentivises new investments in assets that can offer flexibility on an intraday and multi-day basis, while providing seasonal reliability. To mitigate the risk of a crowding-out effect, capacity is restricted from normal wholesale market operations and activated exclusively during periods of critically high market prices, indicating potential capacity shortfalls. Within-day flexibility is achieved through asset activation within the intraday market, necessitating specific adjustments to eligibility criteria. Market-based activation enhances operational efficiency by reducing the need for explicit dispatch instructions from Transmission System Operators (TSOs).

Main design features: Dispatchable flexible reserve represents a new yet recognisable concept, functioning similarly to a strategic reserve by providing dedicated, restricted capacity, but with enhanced flexibility. These reserves are activated exclusively during critically high-price periods within the Single Intraday Coupling (SIDC), the preferred variant, or alternatively within the Single Day-Ahead Coupling (SDAC), contingent upon acceptable merit order distortion levels – to be determined by decision makers. Delaying activation until closer to delivery through SIDC provides the market with opportunities to respond to price signals and resolve capacity issues independently, thereby minimising market distortion.

The design explicitly aligns with the NFFSS regulation, aiming specifically at incentivising new investments in non-fossil flexible capacity. Compared to traditional strategic reserves, typically used to prolong the operational life of existing ageing assets, dispatchable flexible reserve is likely to incur higher per-MW costs due to their requirement for new or refurbished capacities. However, these reserves offer superior flexibility in terms of eligible asset classes and activation approaches. Unlike conventional strategic reserves that necessitate operationally complex, last-resort dispatch instructions by TSOs, a dispatchable flexible reserve enables direct activation within existing market mechanisms. This capability ensures robust within-day and multi-day flexibility and reduces operational complexity for TSOs.

Potential risk: The primary risk associated with this design is merit order distortion. Ringfencing or restricting assets may, in some instances, lead to situations where these assets are more cost-effective for dispatch than those dispatched through the wholesale market. This could result in inefficiencies if the mechanism unintentionally displaces otherwise economically optimal market-based dispatch decisions. Furthermore, by providing a backstop capacity in the market, this mechanism may depress electricity prices and discourage new investments in peaking capacity or Demand-Side Response (DSR). Policymakers must carefully balance the extent of ringfencing or restrictions to mitigate this risk while ensuring system reliability and investment incentives remain intact.

1.2.2 FRR availability obligation

Recommended implementation: The FRR availability obligation is specifically recommended to mitigate risks associated with interconnection outages, particularly in scenarios of low renewable output. It aims to address local flexibility shortfalls and enhance system reliability in regions heavily dependent on interconnections with other markets.

The integration of common aFRR and mFRR Energy Activation Markets (EAM) platforms, PICASSO and MARI, across Europe strengthen reliability by facilitating cross-border balancing service sharing. Additionally, the Nordic dimensioning methodology forecasts future imbalances and procurement needs for aFRR and mFRR, generating price signals to incentivise investment. However, the missing money problem may require additional mechanisms to close potential investment gaps in FRR.

Main design features: This mechanism builds on the existing FRR Capacity Market (CM) but introduces longer lead-times and contracts specifically targeting new investments in non-fossil flexible capacity. Providers must at least meet FRR eligibility criteria.

Given the regulatory limitations of balancing markets, this design is proposed under the NFFSS regulation to accommodate longer lead-times. Like the FRR CM, the FRR availability obligation requires contracted assets to bid into either the mFRR or aFRR EAM, depending on system needs.

Potential risk: Market distortion risk, potentially affecting EAM prices, locally and in neighbouring markets, causing a crowding-out effect.

1.2.3 Strategic reserve 2.0

Recommended implementation: Addressing rare but critical adequacy gaps such as extreme weather events combined with large, unexpected outages. The contracted generation or demand-side capacity is kept outside the market and activated only when needed to prevent market distortion. It ensures availability of additional capacity during multi-day or seasonal shortages. It does not provide real-time or within-day flexibility unless combined with other products. Within-day flexibility is possible to achieve with warming contract and/or products designed to attract more flexible units, complementing slower-reacting, potentially legacy, assets. Real-time flexibility can be ensured through combination with FRR availability obligation.

Main design features: Strategic reserves is a targeted mechanism in which a central body procures capacity that is ringfenced from the market, activated only in severe critical events. If activated, the imbalance price is settled at VoLL or the price cap in the intraday market, whichever is highest. The 2.0 version of the strategic reserve is designed to address the limitations of traditional strategic reserve schemes, namely:

- A lack of eligible MW for reservation.
- Inflexibility due to long ramp-up times.
- Complex TSO last resort dispatching rules.

Key improvements include:

- Lowering entry barriers by expanding eligibility to new asset types, such as extending the ability of complementing heat pumps and electric boilers with biomass/thermal boilers. The scheme should also facilitate DSR participation and, in certain cases, support new investments in flexible assets.
- Enhancing dispatch speed through:
    - Warming contracts, which initiate asset start-up, reducing the time needed for ramping up unit.
    - Introducing a two-product approach if faster ramping is required, one product for fast activation and another following traditional eligibility criteria.
    - Alternatively, this design can be integrated with an FRR availability obligation to meet faster ramping needs.
- Optimising ramping speed and reducing complexity by reviewing TSO dispatching rules related to dispatch instructions. Additionally, warming contracts may be linked to market prices, for instance, automatic activation of warming contract when the SDAC max price threshold is reached.

This approach ensures strategic reserves remain both effective and adaptable, improving system reliability while integrating a broader range of flexible assets.

Potential risk: By ringfencing specific assets, strategic reserve 2.0 may lead to inefficient dispatch if these assets are more cost-effective than market-based alternatives, potentially undermining economic efficiency. Policymakers must strike a careful balance between mitigating this risk and maintaining both system reliability and investment incentives to ensure a well-functioning electricity market.

1.2.4 Market-wide CRM

While the report does not explicitly recommend market-wide CRMs, it acknowledges their potential benefits. Under ideal implementation, they may incentivise new investments with minimal market distortion. With appropriately designed contracts and products, they can also attract the right type of flexible assets to address specific needs. Moreover, eligibility criteria could be structured to limit capacity payments to non-fossil assets.

The report refrains from recommending market-wide CRMs due to two key factors: (1) the substantial financial commitments associated with broad capacity payments, which pose significant risks of failing to achieve intended outcomes due to their sensitivity to unpredictable market developments; and (2) the specific conditions of the Nordic region, which generally benefits from ample capacity and flexibility under normal circumstances, rarely necessitating additional resources. The report assume only relatively small volumes would be needed in the end.

Furthermore, market-wide CRMs are particularly vulnerable to inaccuracies in derating factors, potentially misallocating support to unsuitable assets. Setting derating factors for hydropower with reservoir is especially challenging due to the complexities of water value calculations.

As a result, targeted and, to some extent, ringfenced mechanisms are considered more suitable for addressing any identified capacity or flexibility gaps in the Nordics.

1.3 Additional key takeaways

1.3.1 Cost recovery

In principle, the cost of the scheme should be recovered from those who cause the requirement for the scheme. Generally, this can be linked to peak demand, suggesting that the associated levy should be targeted at peak consumption. Such an approach would not only ensure a fair allocation of costs, but also serve as an additional price signal, encouraging greater deployment of demand-side response (DSR) and thereby helping to reduce both the size and overall cost of the mechanism. Consequently, the needs assessment, which underpins the determination of volume requirements, should reflect this, ensuring that the impact is incorporated into the capacity or flexibility volumes ultimately procured.

Strategic Reserves 2.0, however, may be considered a justified exception to this principle. As a last-resort instrument, activated only under extreme system stress and after all market-based solutions have been exhausted, it serves a broader system integrity function rather than addressing regular peak demand. In this context, targeted cost recovery would be inappropriate

1.3.2 Cross-border participation

As a general principle, cross-border participation is recommended to prevent distortions in neighbouring markets and enhance overall welfare. However, this report acknowledges both the opportunities and challenges associated with cross-border participation.

For market-wide CRMs, it is recommended enabling cross-border participation while recognising its complexities.

For targeted mechanisms, the recommendation depends on the specific design and purpose. Targeted mechanisms are typically introduced to address market failures in a specific country when decoupled from neighbouring areas. Allowing foreign capacity participation could dilute their intended effect. Based on this, strategic reserve 2.0 and the FRR availability obligation are recommended as national schemes without cross-border participation.

For dispatchable flexible reserve, the case for cross-border participation is stronger if multiple countries have a need for and implement this mechanism. In such cases, the likelihood of transmission constraints during scarcity events should be accounted for by applying appropriate derating factors.

1.3.3 Regional harmonisation

To mitigate future challenges and reduce potential negative cross-border impacts, it is recommended that Nordic decision-makers establish an early consensus on the following key areas:

- **Needs assessment:** Harmonise adequacy and flexibility assessments across the Nordic countries to ensure a consistent approach. Aligned timing is also key, to prevent freeriding.
- **Value of Lost Load (VoLL):** Where relevant, use a common methodology for defining VoLL, in line with ACER's recommendations in their Security of Supply 2024 report at the European level.
- **Regulatory harmonisation:** Where applicable, adopt a coordinated approach to CRM or NFFSS regulations to enhance market efficiency.
- **Platform cooperation:** For markets introducing new mechanisms, explore shared procurement systems. Even if mechanisms differ, certain features can be standardised. A common system provider can help reduce costs and improve interoperability.

↑ Photos: Energinet and Fingrid Oyj

2. Setting the scene: Context and rationale for CRM and NFFSS in the Nordic Region

This chapter sets the scene for the rest of the report, providing essential background on the growing interest in exploring new market mechanisms to support the green transition in the Nordic region. It offers key insights into the Nordic energy landscape and explores potential shortcomings of energy-only market designs. The regulatory framework is outlined, followed by an examination of country-specific challenges and the definition of likely scarcity events. The analysis also highlights the substantial costs associated with addressing these challenges if not managed effectively. Finally, it considers the technologies and capabilities required to respond to emerging issues, identifying both constraints and opportunities for future market design.

2.1 Summary

The green transition and the electrification of society require substantial investments to support increasing electricity demand. Simultaneously, the recent energy crisis and geopolitical tensions have underscored the importance of energy security for the Nordic countries. Historically, the Nordic electricity market has largely relied on an energy-only market model to ensure sufficient capacity, with limited exceptions. However, growing uncertainty regarding future electricity price developments has led stakeholders to question whether market signals alone will be sufficient to drive investment in the necessary assets.

This evolving market landscape raises the critical question of whether some form of capacity or flexibility mechanism is required to maintain adequate levels of firm capacity and flexibility, ensuring a secure electricity supply. While there is a clear need to guarantee system adequacy and flexibility, any intervention must be carefully weighed against its associated costs. CRM payments have expanded significantly across continental Europe in recent years. According to ACER, annual capacity payments for market-wide CRMs range from approximately €20,000 to €60,000 per MW. Applying this range to the Nordic region's peak demand of approximately 65 GW in 2023 suggests that such payments could amount to €1.3–3.9 billion per year. Of course, different assumptions—such as not covering the full peak demand—could lower this cost, but ACER's figures highlight that CRMs come with a significant price tag.

Additionally, the availability of emerging technologies must be considered to ensure that any potential CRM design does not inadvertently hinder their future contributions to system adequacy and flexibility. The design of mechanisms in the Nordic context must therefore strike a balance between ensuring security of supply and minimising costs while maintaining technological neutrality, to the extent possible, to facilitate innovation and long-term sustainability.

2.2 The Nordic energy-only market

The Nordic energy market is a pioneering example of a liberalised electricity market in Europe, encompassing Denmark, Finland, Norway, and Sweden. This market operates on the principles of competition and transparency, allowing various market participants, including producers, consumers, and traders, to engage in the buying and selling of electricity. Notably, the Nordic market was highly integrated even before the wider EU integration seen in recent history, demonstrating a strong tradition of regional cooperation and shared infrastructure.

In the Nordic context, an energy-only market refers to a market design in which investors must rely on market price signals alone to justify investment in a sufficient volume of assets to ensure security of supply. Legislation requires that electricity market reforms are taken into account before the possible introduction of a capacity mechanism. This study recognises that the Nordic markets can be improved in their efficiency and in their ability to provide security of supply, but a discussion of electricity market reform within the concept of the energy-only market was not within the scope of this study.

2.2.1 Marketplaces for electricity

The Nordic energy market is structured around several key marketplaces, including the Single Day-Ahead Coupling (SDAC) and the Single Intraday Coupling (SIDC). These marketplaces, commonly referred to as the day-ahead and the intraday markets, respectively, are essential for maintaining the instantaneous physical balance between electricity supply and demand.

The SDAC market allows participants to plan their production and consumption for the next day, providing a reference price for electricity trading across the region. This market is vital for ensuring that supply meets demand in a cost-effective manner, as it enables market participants to optimise their operations based on forecasted conditions. Additionally, it allows Transmission System Operators (TSOs) to plan for the operation of the electricity system the next day, ensuring that they can manage grid stability and reliability effectively.

The SIDC market, on the other hand, serves as a correction mechanism, allowing participants to adjust their positions closer to real-time as more accurate information becomes available. The market consists of both continuous trading as well as three daily intraday auctions (IDAs). The intraday market is crucial for addressing any discrepancies between forecasted and actual conditions, ensuring that the system remains balanced.

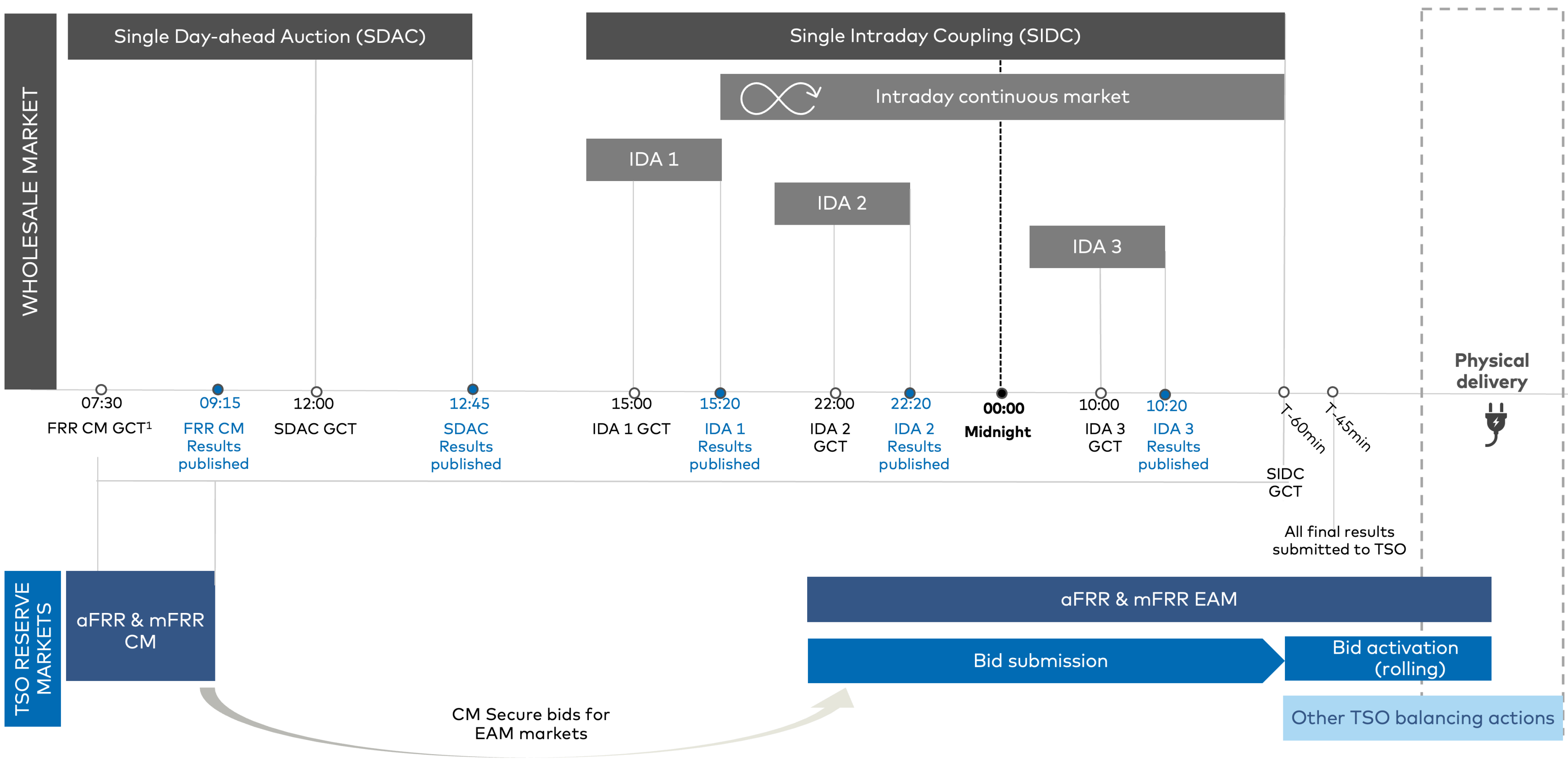
Additionally, the balancing markets, managed by the TSOs, plays a critical role in maintaining real-time balance. The TSOs use this market to procure automatic and manual reserves, which are necessary to address any imbalances that occur during the operational hour. This ensures that the electricity system can respond to unexpected changes in supply or demand, maintaining overall system stability.

These marketplaces are designed to provide clear price signals and incentives for market participants, encouraging efficient resource allocation and investment in capacity when needed from a system perspective. These markets are essential for ensuring a reliable and secure electricity supply, while also facilitating the integration of renewable energy sources and supporting the overall goals of the energy transition.

Exhibit 2.1 illustrates the timeline of the key marketplaces within the Nordic wholesale electricity market.

Exhibit 2.1 – Overview of the Nordic wholesale electricity market

The physical wholesale electricity market operates from the day-ahead stage to the real-time



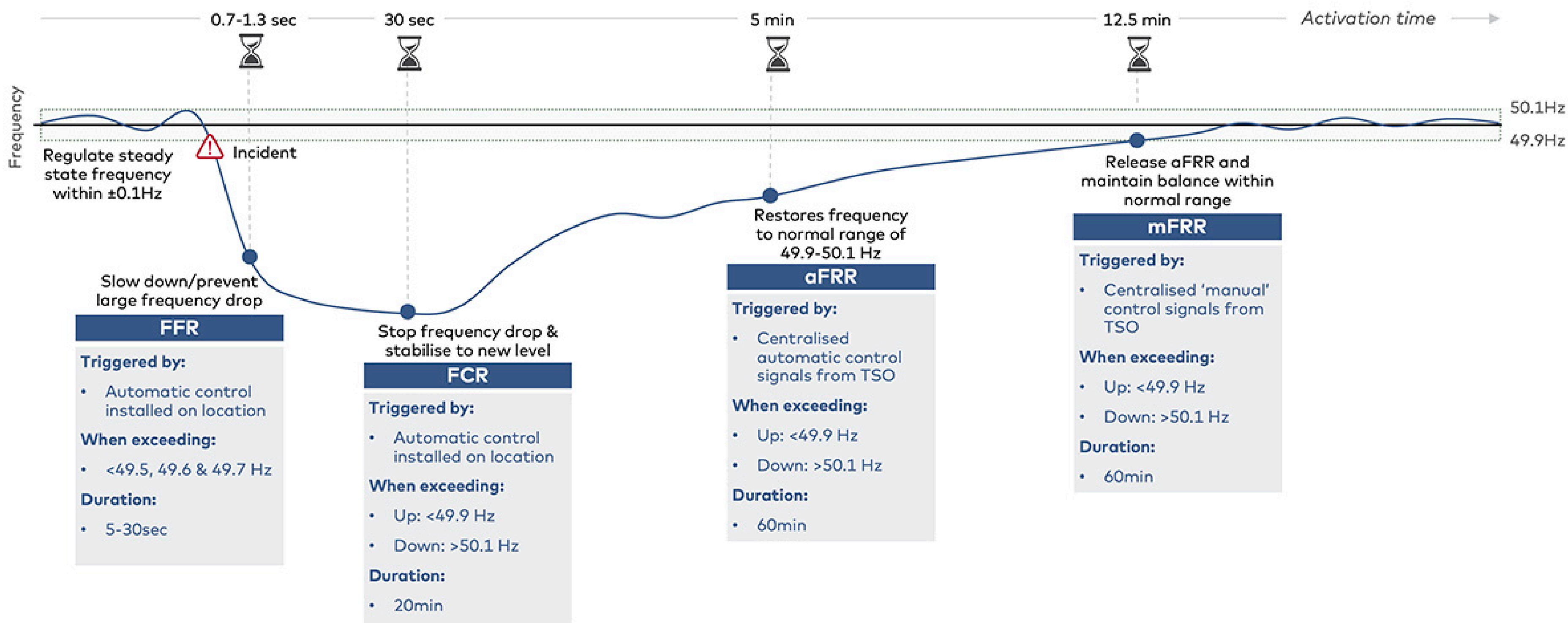
(1) GCT=Gate Closing Time

Source: AFRY

The figure includes Automatic Frequency Restoration Reserves (aFRR) and Manual Frequency Restoration Reserves (mFRR), covering both the Capacity Market (CM) and the Energy Activation Market (EAM), which are most relevant for this report. In addition to these, the main ancillary services in the Nordics also comprise Fast Frequency Reserve (FFR) and Frequency Containment Reserve (FCR). Exhibit 2.2 illustrates how these markets interact to manage disturbances in the power grid, highlighting the roles of FCR, aFRR, and mFRR in maintaining system stability. Further details on each individual market are provided below the figure.

Exhibit 2.2 – Balancing reserves in the Nordic Region

Balancing reserve markets ensure that the frequency is restored to the acceptable range



Source: AFRY

Fast frequency reserves (FFR) helps maintain grid stability by quickly responding to sudden changes in frequency. This rapid response is typically required for a short period until other reserves can take over. Participants, such as batteries and DSR entities, submit bids in annual auctions and are compensated by the TSO.

Frequency containment reserves (FCR), or primary reserves, are used for constant control of the system frequency, regulating it at 50Hz. FCR-N stabilises the frequency of small production and consumption changes, while FCR-D stabilises the frequency if it deviates significantly from the defined range.

Automatic frequency restoration reserves (aFRR), or secondary reserves, are activated to replace FCR and restore frequency to the normal range. An automatic signal from the TSO adjusts the production or consumption of providers.

Manual frequency restoration reserves (mFRR), or tertiary reserves, has the purpose to take over from aFRR and maintain balance until the power market restores balance. It is the main balancing resource of the Nordic power system due to the limited availability of aFRR and grid congestions.

Both aFRR and mFRR consist of a capacity market and an energy activation market, which can generally be described in the following manner:

- **aFRR/mFRR capacity market (CM)**: Participants bid their available capacity to adjust energy up or down each hour. Accepted capacity bids are remunerated independently of whether bids in the subsequent EAM are activated or not. Each Nordic TSO is responsible for procuring a quantity corresponding to the dimensioning error in their system plus quantities needed for congestion management.
- **aFRR/mFRR energy activation market (EAM)**: Accepted CM bids are transferred to EAM. New participants can also bid in the EAM regardless of being accepted in the CM. Energy activation is compensated according to the clearing price per hour for each price zone. Upward regulation occurs when additional generation is required to balance the system, while downward regulation occurs when generation needs to be decreased, or consumption increased.

2.3 Missing money problem

The business case for new firm and flexible capacity is often challenging due to the infrequent operation of 'backup' capacity, which is primarily needed during rare weather conditions or when the electricity systems is experiencing major outages. This infrequency leads to significant price and volume risks, which is the core of the missing money problem. The energy-only market can, among investors, be perceived as unable to provide sufficient price signals to attract investments in supply security, making new firm and flexible investments appear unattractive solely on merchant market operations. The result is inadequate financial incentives to secure enough capacity to manage supply shortages during these critical periods.

To solve the missing money problem, different types of capacity and/or flexibility mechanisms can be implemented to address various challenges. These mechanisms can support not only generation but also demand-side flexibility and storage solutions. Since different mechanisms will attract different types of investments, it is essential to design them carefully to target the appropriate forms of capacity that can effectively mitigate the identified issues and ensure a reliable electricity supply. By offering additional revenue streams, such mechanisms can help secure sufficient firm and flexible capacity.

However, the implementation of any such mechanism should be considered a measure of last resort, as further discussed in Chapter 2.4.

2.4 Regulatory background

This section examines the regulatory framework underpinning Capacity Remuneration Mechanisms (CRMs) and Non-Fossil Flexibility Support Schemes (NFFSS). This includes the amendments to Regulation (EU) 2019/943.

It is important to note that, before implementing a mechanism, a thorough resource adequacy assessment must be conducted[1]. A key element of the assessment is to identify the root cause of the issue and develop a market reform plan to improve the wholesale market design and address the root cause. The functioning of the Nordic electricity market can certainly be improved, but a discussion of the energy-only market design is outside the scope of this study.

Only as a measure of last resort, where it is clearly demonstrated that improvements to the energy-only market are insufficient to resolve the problem, should a capacity mechanism be introduced[2]. Moreover, the design of such a mechanism must comply with EU state aid rules, ensuring that it is necessary, proportionate, and appropriately targeted.

2.4.1 Capacity remuneration mechanisms (CRMs)

As described by ACER in the 2024 Security of EU electricity supply report, "*Capacity mechanisms are support schemes that remunerate capacity resources (e.g. generators, demand-response or storage units) to be available in return of providing security of supply services*".

The regulatory framework for CRMs is primarily governed by Regulation (EU) 2019/943 on the internal market for electricity. To implement a CRM, several key steps must be followed to ensure compliance:

1. **Resource adequacy assessment**: Conduct a thorough resource adequacy assessment as part of the European Resource Adequacy Assessment (ERAA) and national reports. This assessment should be updated annually to identify potential adequacy concerns.
2. **Market reform plan**: Develop a market reform plan to address identified adequacy issues and improve the wholesale market design. This plan should aim to resolve issues within the energy-only market before considering a CRM.
3. **Notification and approval from the European commission**: Notify the European Commission of the intention to implement a CRM and obtain approval. This notification should include the results of the resource

1. For CRMs this methodology already exists, while for NFFSS it is currently under development.
2. European Union (2019), Regulation (EU) 2019/943, Art. 21(1); European Commission (n.d.), Capacity mechanisms, available at: https://energy.ec.europa.eu/topics/markets-and-consumers/capacity-mechanisms_en

adequacy assessment and the market reform plan, ensuring the CRM design meets all regulatory criteria (see below).

4. **Implementation and monitoring**: Implement the CRM and establish mechanisms for regular monitoring and evaluation to assess its impact and effectiveness.

CRMs must adhere to several key design principles:

- **Transparency and non-discrimination**: Ensuring clear rules and procedures for participation, including open access to all capacity providers, including cross-border participants.
- **Competitiveness**: Selecting capacity through auctions or other market-based mechanisms to ensure cost-effectiveness. Therefore, price-based designs are practically excluded.
- **Proportionality**: Addressing only the identified adequacy concerns without exceeding what is necessary.
- **Avoiding undue market distortions**: Ensuring CRMs do not limit cross-zonal trade and maintain a level playing field.
- **Monitoring and evaluation**: Implementing mechanisms to regularly assess the impact and effectiveness of CRMs.

Other important regulatory aspects to consider include ensuring that CRMs support the integration of renewable energy sources and contribute to the EU's climate goals. It is also crucial to design CRMs in a way that minimises costs to consumers while ensuring security of supply. Furthermore, the CRM should be technologically neutral, allowing for a diverse range of capacity providers without favouring specific technologies.

2.4.2 Strategic reserves

The implementation of a strategic reserve follows the same steps as for CRMs, including conducting a resource adequacy assessment, developing a market reform plan, notifying and obtaining approval from the European Commission, designing the reserve, and establishing mechanisms for monitoring and evaluation. However, strategic reserves differ from CRMs in several ways:

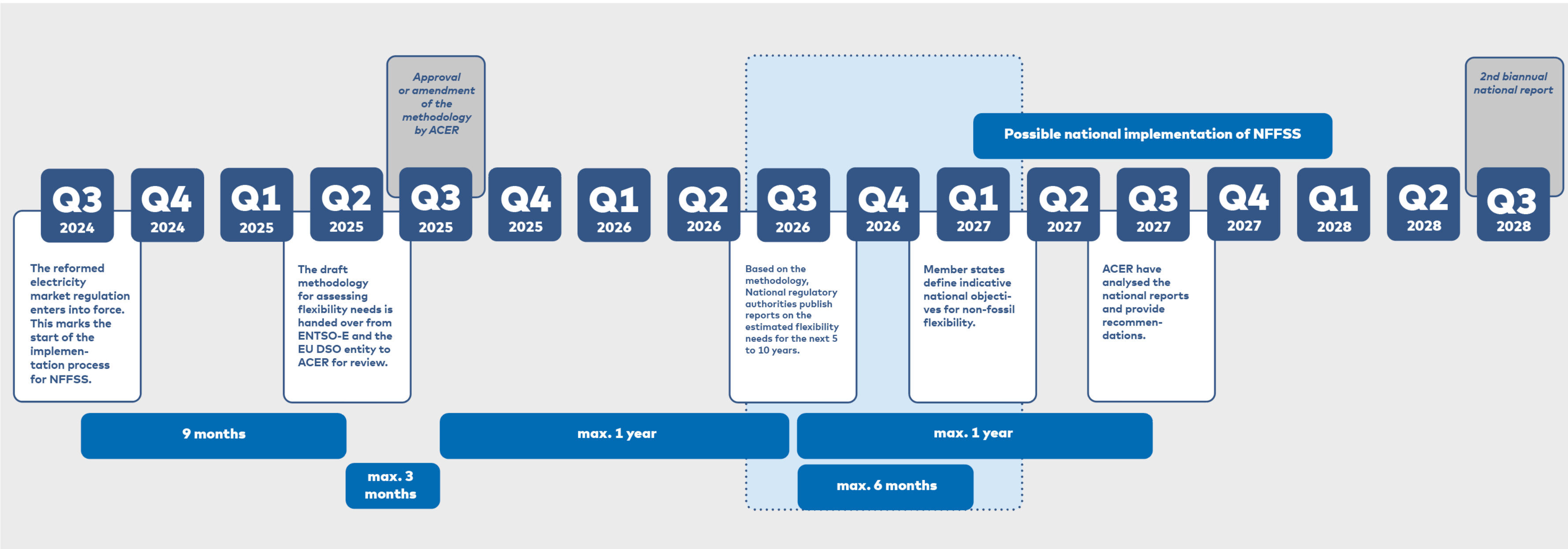
- **Market participation**: Strategic reserves are kept outside the electricity market and are only used when market participants do not offer enough generation to meet demand. In contrast, CRMs are integrated into the market and provide payments to capacity providers to ensure availability.
- **Activation**: Strategic reserves are activated only in emergency situations or when there is a significant shortfall in generation. CRMs, on the other hand, provide regular payments to capacity providers to ensure they are available when needed.
- **Control**: Strategic reserves are typically controlled by the TSO, while CRMs involve market-based mechanisms and competitive auctions.

2.4.3 Non-Fossil Flexibility Support Schemes (NFFSS)

The Non-Fossil Support Scheme (NFFSS) is a new tool which aims to support roll-out of renewable energy by securing sufficient flexible, green capacity in the grid, by open up for new and greener approaches to supporting investment in flexible resources. It is not only a tool, but also an obligation on member states to assess the need for flexibility and set national targets for flexibility. The process for implementing these provisions involves several key steps, as showing in Exhibit 2.3.

Exhibit 2.3 – Key steps in implementation of amendments to Regulation (EU) 2019/943 with regard to NFFSS

First likely implementation of NFFSS in 2027



Source: AFRY, Regulation (EU) 2019/943.

The key distinction between conventional CRMs and the NFFSS is its targeted approach, rather than a market-wide application. The NFFSS is designed to promote new, non-fossil, flexible resources. As shown in Exhibit 2.4, its main design principles provide a framework, but the regulation allows Member States the flexibility to tailor and implement support schemes based on national circumstances. However, the overall design guideline is to ensure a market-based scheme that promotes competition and avoids distorting the electricity market. If capacity mechanisms are already in place, it should be adjusted to incentivise non-fossil flexibility.

Exhibit 2.4 – Design principles for NFFSS

Regulation (EU) 2019/943 lays down a range of design principles for NFFSS

Cost-effectiveness: Ensure that the scheme does not go beyond what is necessary to achieve the indicative national objective in a cost-effective manner.	Targeted support: The support is limited to new investments in non-fossil flexibility resources (see below for more details).
Locational criteria: Consider locational criteria to ensure investments take place in optimal locations.	No fossil fuel-based generation: Ensure the scheme does not imply starting fossil fuel-based generation located behind the metering point.
Competitive selection: Select capacity providers through an open, transparent, competitive, voluntary, non-discriminatory, and cost-effective process.	Prevent distortion: Prevent undue distortions to the efficient functioning of electricity markets, preserving efficient operation incentives and price signals.
Market integration: Provide incentives for market-based and market-responsive integration, avoiding unnecessary distortions and considering system integration costs and grid stability.	Minimum participation: Set a minimum level of participation in the electricity markets in terms of activated energy, considering the technical specificities of the asset delivering the flexibility.
Penalties: Apply appropriate penalties to capacity providers that do not meet the minimum participation levels or follow efficient operation incentives and price signals.	Cross-border participation: Promote cross-border participation of resources capable of providing the required technical performance, where a cost-benefit analysis is positive.

Source: AFRY, Regulation (EU) 2019/943.

The wording in Article 19(h)(b) of the amended Regulation (EU) 2019/943 states that non-fossil flexibility support schemes must be "limited to new investment in non-fossil flexibility resources such as demand-side response and energy storage." In our view, the phrase "such as" suggests that DSR and energy storage are examples rather than an exhaustive list, meaning other non-fossil flexibility resources could potentially be eligible.

The key criterion is "flexibility." The regulation is specifically designed to support resources that enhance the power system's ability to respond dynamically to fluctuations in supply and demand. Which technologies that can receive support therefore would depend on their demonstrated ability to provide short-term flexibility, but also on the final methodology for assessing flexibility and how the rules are implemented nationally.

2.4.4 State aid

All capacity and flexibility mechanisms must comply with General Block Exemption Regulation (GBER)[3] state aid rules, requiring approval from the European Commission to ensure they do not distort competition within the internal market.

Firstly, the aid must address a genuine market failure or achieve an objective of common interest, such as ensuring security of supply or integrating renewable energy sources. The measure should be necessary and proportionate, meaning it should not exceed what is required to achieve its objective and should be the least distortive alternative available. In the context of capacity mechanisms, they must be designed to address specific adequacy concerns.

Secondly, the aid must have a limited impact on competition and trade within the EU. The Commission evaluates whether the measure provides undue advantages to certain companies or sectors, potentially harming competitors and affecting trade between Member States. For example, capacity mechanisms must be open to all capacity providers, including cross-border participation, to prevent market fragmentation.

Lastly, transparency and monitoring are crucial components of the approval process. Member States must ensure that the aid measure is transparent, with clear rules and procedures for granting aid, and must regularly monitor and report on its implementation and impact. This helps the Commission verify that the aid remains compatible with EU rules over time and allows for adjustments if necessary. Additionally, the aid measure should include mechanisms to prevent overcompensation and ensure that beneficiaries do not receive more aid than needed to achieve the intended objectives.

3. European Commission (n.d.), State aid regulations, available at: https://competition-policy.ec.europa.eu/state-aid/legislation/regulations_en

The Temporary Crisis and Transition Framework for State Aid was introduced in response to the exceptional circumstances caused by the energy crisis, particularly the disruptions in energy supplies stemming from geopolitical tensions (e.g., the war in Ukraine). The framework, which is set to expire on 31 December 2025, allows for more flexible and faster state aid procedures to support investments in the energy sector, including the development of technologies like Battery Energy Storage Systems (BESS). This framework enables governments to grant state aid for projects that enhance energy security and contribute to the transition towards greener and more resilient energy systems.

After the expiration of the Temporary Crisis and Transition Framework in December 2025, the rules for granting state aid will revert to the regular framework, which typically have stricter conditions regarding direct investment support.

2.5 Country and area specific challenges

TSOs conduct detailed analyses to forecast future resource adequacy, identifying potential gaps between supply and demand. The European Resource Adequacy Assessment (ERAA) is a Europe-wide yearly report conducted by ENTSOE. The ERAA provides valuable insights into the anticipated needs and challenges that TSOs foresee, helping to inform strategic decisions and policy measures to secure the electricity supply in the coming years. In addition, the Nordic TSOs publish country specific reports where they analyse the future resource adequacy.

In the next sub-chapter, a high-level overview of the Nordic Region is presented. Chapter 2.5.3-2.5.6 contains more country specific details.

2.5.1 Nordic context

The Nordic electricity grid is facing an increasingly complex set of challenges as each country, Denmark, Norway, Sweden, and Finland, navigates the need for enhanced flexibility and capacity to ensure grid stability and reliability. Denmark, for instance, is grappling with the phase-out of Combined Heat and Power (CHP) plants in favour of renewables, raising concerns about the adequacy of flexibility to manage future system operations. In Norway, dry years can trigger adequacy risks, particularly in southern Norway, where the reliance on hydropower faces seasonal limitations. Sweden's energy-only market currently struggles to provide the necessary flexibility to meet reliability standards, with southern Sweden being particularly vulnerable to adequacy risks under dry conditions and facing persistent bottlenecks in power transmission from the north. Meanwhile, Finland's challenges are primarily centred around maintaining electricity adequacy during prolonged cold periods with low wind conditions or disruptions in generation or imports.

Each nation has defined a reliability standard to measure if measures are needed to improve the resource adequacy. This is typically stated in terms of how many hours per year they expect loss of load and is referred to as Loss of Load Expectation (LOLE). The ERAA 2023 report indicate that under normal weather conditions (scenario A, the Central Reference) the LOLE remains modest for the Nordic region, but the 2023 Security of EU electricity Supply report shows that Denmark, Sweden and Finland may have adequacy concerns during any of the next 10 years.[4]

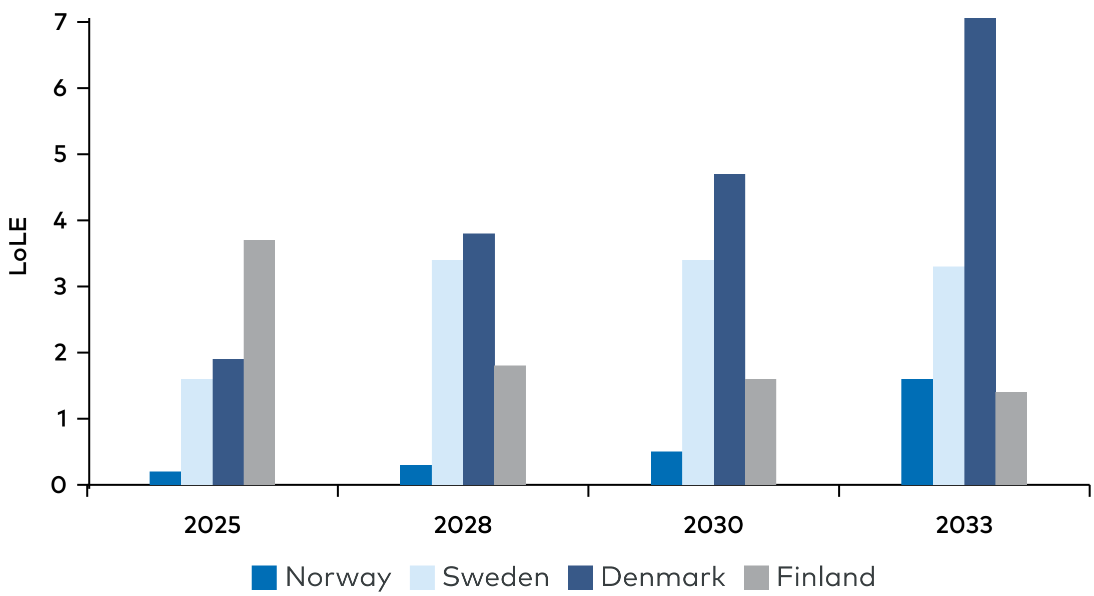


Exhibit 2.5 – LOLE expectations in the ERAA 2023

Some areas have higher LOLE expectations, like Sweden and Denmark

Source: ENTSO-E.

4. ACER (2023), Security of EU electricity supply 2023, Figure 2, p. 30. Available at: https://acer.europa.eu/sites/default/files/documents/Publications/Security_of_EU_electricity_supply_2023.pdf

To explore the resource adequacy situation further, all of the Nordic TSO have conducted their own analysis on top of the ERAA. In essence, the country specific situation can in short be summaries in the following bullets:

- **Denmark**: Heavily impacted by RES fluctuations and limited domestic adjustable supply. High dependency on interconnectors to solve real-time and within-day fluctuations.
- **Sweden**: In dry years, internal grid bottlenecks may create dependency on cross-border interconnectors to supply sufficient energy in southern Sweden.
- **Finland**: Strong internal grid, but dependent on interconnectors to adjacent markets under certain conditions.
- **Norway**: Abundant capacity from hydropower. In dry years, internal grid bottlenecks may create dependency on interconnectors to supply sufficient energy in some regions.

Drawing on the reports referenced in this chapter, as well as feedback from Nordic Energy Research, Exhibit 2.6, has been developed to illustrate the high-level characteristics of the Nordic region towards 2030 in the context of resource adequacy. The illustration distinguishes between Nordic connected capabilities—representing conditions when all interconnectors are operational—and national capabilities, to demonstrate how risk profiles change when only domestic resources are considered.

The temporal dimension is defined in the following manner:

- **Real-time:** Ability to adjust within seconds/minutes to support system balancing.
- **Within-day:** Manage fluctuations in supply and demand that occur within-day, including morning and evening peaks, as well as day-night differences in RES.
- **Multi-day:** Adapt to changes in demand & supply over several days, incl. weekdays/weekends differences, weather-driven fluctuations in RES, and interconnector outages.
- **Seasonal:** Adjust to differences in seasonal demand shifts and differences in RES generation driven by seasonal weather patterns. Must also account for dry seasons.

Exhibit 2.6 – High-level characteristics of the Nordic region towards 2030 in the context of adequacy

The Nordic connected capabilities are overall fair, but the risk increases when only considering national resources

	Nordic connected apabilities				Notopnal capabilities (disconnected)			
	Real-time	Within-day	Multi-day	Seasonal	Real-time	Within-day	Multi-day	Seasonal
FI	Fair	Fair	Fair	Fair	Risk	Risk	Risk	Fair
DK	Risk	Risk	Fair	Fair	Risk	Risk	Risk	Fair
SE	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair
NO	Good	Good	Fair	Fair	Good	Good	Fair	Risk

Source: AFRY

In the ERAA 2023 report, ENTSOE writes that "*Being an inherently complex study, ERAA is characterised by a significant degree of uncertainty and computational constraints*" and that "*(…) assumption for a same given target year can evolve fast from one edition to another, due to the ongoing accelerating energy transition*"[5]. In other words, the future resource adequacy situation may relatively quickly change.

Given this uncertainty, it is more appropriate to develop a flexible toolbox of mechanisms that can be adapted to shifting needs over time. As designing a truly technology-neutral, one-size-fits-all market mechanism is not feasible, this report aims to recommend the mechanism(s) best suited to promote the technologies most capable of addressing the identified adequacy challenges.

2.5.2 Issues causing scarcity events

Drawing on existing research and published reports, it is assumed that scarcity events are primarily a concern in scenarios where multiple conditions arise simultaneously. The identified events include:

Cold winters: As a large share of the Nordic space heating demand is covered by electricity, cold weather gives an increase in demand. This can result in:

5. ENTSO-E (2023), European Resource Adequacy Assessment (ERAA) 2023, available at: entsoe.eu

- a day-to-day peak in demand, causing a capacity problem; or
- a large increase in demand from one week or month to the next, or even from one winter to the next, potentially giving rise to an energy problem.

Dry years: As a substantial share of the Nordic electricity generation capacity stems from hydropower, years with low participation will see substantially lower generation. This may give rise to an energy problem.

Low intermittent RES output: This may give rise to different challenges, among them:

- to balance the electricity system within-day during high short-term fluctuations, giving rise to a flexibility problem; or
- a day-to-day capacity problem; or
- an energy problem during dunkelflaute events.

Supply outages: The unavailability of one or more large generation units, for example nuclear units running baseload, may lead to:

- a capacity problem if the outage is short; or
- an energy problem if the outage is long.

Interconnector outages: Some Nordic price areas rely on interconnectors for resource adequacy, and their outage have a similar impact as supply disruptions described above. In recent years, the risks associated with interconnector failures have become more apparent, as incidents such as accidents or possibly sabotage have led to prolonged outages of underwater HVDC lines, lasting several months.

One of the five events above may not necessarily cause a problem on its own. Scarcity is more likely to occur when multiple events coincide. The probability of scarcity decreases as more events must align to create such a situation. The likelihood of individual events and their correlation with each other should guide the choice of solutions, keeping in mind that historical patterns may not reliably indicate future needs.

Furthermore, anticipated scarcity events should inform the eligibility criteria of the mechanism. The type of technology needed (being storage, DSR, capacity, and/or energy) to cover the shortfall, each requires specific considerations when designing the mechanism to make sure it effectively solves the issue.

All these aspects needs to be considered when designing a potential new mechanism for the Nordic market.

2.5.3 Denmark

The Danish electricity grid is currently facing significant challenges as, over time, there has been a growing risk that the available generation capacity will not be sufficient to meet the electricity demand. This issue is exacerbated by the decline in controllable thermal capacity and an expected rise in electricity consumption, both within Denmark and across Europe.

According to "Redgjørelse for elforsyningssikkerhed 2023", a report published by Energinet, there is a growing risk of insufficient capacity in the day-ahead market to meet electricity demand, as well as a potential shortage of balancing reserves. This is threatening the overall adequacy of the electricity supply.[6]

Energinet's analysis suggests that the issue is best mitigated through new controllable production capacity or DSR. While strong interconnection have historically been a cornerstone of Danish supply security, new capacity on these connectors will only partially alleviate the problem as the problem of capacity shortages may arises at the same time across Europe. Typically, this will happen during periods of low solar and wind production. Energinet also anticipates a need for more system services and balancing reserves to manage larger and more frequent imbalances in the future electricity system.

One potential solution to the risk of capacity shortfalls is the introduction of a capacity mechanism. Energinet, in collaboration with the Danish Energy Agency, is conducting a detailed analysis of the prerequisites and possibilities for establishing a capacity mechanism in Denmark. This analysis will explore the advantages and disadvantages of various capacity mechanism models, considering their impact on other markets.

Energinet's initiative, "New ways of balancing the electricity grid of the future," address the complex challenge of balancing a grid based on 100% renewable energy resources (RES). This initiative identifies three main challenges: scarcity situations due to a lack of adjustable capacity during low renewable production periods, insufficient participation and liquidity in normal periods, and outages of large plants due to extreme weather. Energinet is exploring five opportunity spaces to find specific solutions to these problems.[7]

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6. Energinet (2023), Redegørelse for elforsyningssikkerhed 2023, available at: https://energinet.dk/om-publikationer/publikationer/redegorelse-for-elforsyningssikkerhed-2023/
7. https://energinet.dk/om-publikationer/publikationer/redegorelse-for-elforsyningssikkerhed-2023/

2.5.4 Sweden

Sweden is facing increasing challenges with resource adequacy in the electricity market, leading to periods of high electricity prices and a heightened risk of power shortages and subsequent load shedding. Recent national and European analyses by Svenska kraftnät (Svk) indicate that Sweden may soon fail to meet the established reliability standard of one hour. The anticipated electrification is driving up electricity demand, but there are significant uncertainties regarding future electricity usage. This creates substantial risks for investors, negatively impacting decisions on new production capacity investments.

The energy transition is expected to result in a significant increase in electricity consumption and a shift in the production mix towards a higher share of renewable and weather-dependent electricity generation, however, not matched by a corresponding increase in production capacity to meet demand during peak hours. Svk assesses that the current energy-only market cannot deliver all the necessary flexibility to meet the reliability standard under these circumstances.

Northern Sweden (SE1 and SE2) currently has a surplus of electricity production, which is exported to the consumption-dominated deficit areas in southern Sweden (SE3 and SE4). The rapid expansion of renewable electricity production, particularly in northern Sweden, makes it difficult to eliminate transmission constraints in the grid at the required pace. By 2027, the additional capacity needed to maintain power balance in southern Sweden could reach between 2,500 and 3,000 MW to meet the reliability standard.[8]

Existing flexibility and capacity mechanisms

To ensure a stable power supply, especially during unexpected outages or high-demand periods, Sweden has two additional reserves beyond the energy only market:

- Strategic Reserve (effektreserv): From 2020 to 2025, Sweden's strategic reserve stood at 562 MW, with availability requirement from 16 November to 15 March. This capacity was provided by Karlshamnsverket, an oil-fired power plant, located in SE[9].
- The Strategic Reserve is considered temporary and needs to go through a new EC approval process, with a potential extension for three more years[10].

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8. Svenska kraftnät (2023), Framtidens kapacitetsmekanism för att säkerställa resurstillräcklighet på elmarknaden, available at: svk.se
9. Energiforsk (2024), Contracts for Difference (CfD) in the Swedish Electricity Market, Report No. 2024:991, authored by EA Energy Analyses. Available at: https://energiforsk.se/media/33171/2024-991-contracts-for-difference-cfd-in-the-swedish-electricity-market.pdf
10. Svenska kraftnät (2023), Framtidens kapacitetsmekanism för att säkerställa resurstillräcklighet på elmarknaden, available at: svk.se

- Disturbance Reserve (störningsreserven) – not a capacity mechanism, but rather providing additional flexibility: Used for short-term imbalances in the power system, primarily consisting of old gas turbines on long contracts. Additional reserves are, as a temporally solution[11], procured on an annual basis for the maximum of one year at the time. The reserve can be fully operational within 15 minutes and is activated manually during severe system disturbances.

Challenges with existing mechanisms

While the two reserves have been effective in maintaining system reliability, they face significant challenges. The Strategic Power Reserve, with its temporary nature and limited capacity, may not be sufficient to address prolonged or severe power shortages, especially as it is set to be phased out by March 2025. On the other hand, the Disturbance Reserve, while effective for handling imbalances, relies heavily on gas turbines, which may not align with long-term sustainability goals.

2.5.5 Norway

Currently, Norway enjoys a slight power surplus, even during the tightest hours. However, Norway is moving towards a tighter power balance, and by 2030, there may be hours with a national power deficit. Norway's power system continues to benefit from significant flexibility provided by hydropower plants with reservoirs. The increasing share of new, unregulated, and stochastic production from wind and solar power will not necessarily be available during demand peaks. This variability poses substantial challenges in balancing consumption and production. Hydropower will increasingly shift from full production during high-price periods to minimal production when prices are low.

Norway currently benefits from substantial import capacity, providing a important safety net. However, as the Nordic and European power systems become increasingly reliant on weather-dependent generation, the availability of back-up capacity via interconnectors is expected to decrease. This shift could result in periods of high prices. According to the NVE and Statnett report "Norsk og nordisk effektbalanse fram mot 2030", enhancing flexibility on the consumption and/or production side could offer a buffer during instances when Norway faces a tight power situation concurrently with high prices or capacity shortages across the Nordic or Northern European regions.[12]

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11. Svenska kraftnät (2023), Svenska kraftnät upphandlar kompletterande störningsreserv för SE3 och SE4, published 27 January 2023. Available at: svk.se
12. Norges vassdrags- og energidirektorat (2022), Norsk og nordisk effektbalanse fram mot 2030, NVE Rapport nr. 20/2022, available at: https://publikasjoner.nve.no/rapport/2022/rapport2022_20.pdf

In Statnett's "Et effektivt markedsdesign for fremtidens kraftsystem" report, their assessment indicates no immediate need for a capacity market in Norway's electricity sector for the next 10-15 years. Key factors in this evaluation include the continued operation of existing hydropower, investments in flexible hydropower is sufficiently supported by the energy-only market, and the expectation that new consumption will be more flexible than current levels, driven by higher price variations.[13]

2.5.6 Finland

The Finnish electricity system has maintained an acceptable level of resource adequacy, largely due to significant hydropower capacity and the recent commissioning of Olkiluoto 3 nuclear power plant. Before 2022, electricity imports from Russia played a crucial role, especially during cold winter days. However, these imports have now been mostly replaced by imports from Sweden and increased domestic generation, primarily from wind and nuclear capacity.

In Finland, a challenging weather year is characterised by prolonged periods of high demand coupled with low wind power output. During such years, the power deficit cannot be mitigated by energy storage, DSR, or imports alone. Combined with a growing electricity demand and an increasing share of intermittent wind power, the need for firm and flexible capacity during windless periods becomes more critical. Resource adequacy during these periods can only be achieved with resources that offer long duration or have no energy limitations. In other words, firm and flexible capacity.

In April 2024, Wärtsilä and AFRY published the report "How firm and flexible capacity supports Finland to become a green superpower". It shows that as the Finnish power system evolves, the retirement of older thermal units and the rise in electricity demand from new industries, further stress the importance of reliable capacity. The report highlights that while energy storage and DSR play vital roles, they alone cannot guarantee security of supply during dunkelflaute. The study emphasises that the time to act is now, advocating for the swift implementation of a capacity or flexibility mechanism that is future-proof and capable of adapting to the dynamic needs of the Finnish electricity market.

Existing flexibility and capacity mechanisms

Finland operates an energy-only market theoretically supported by a strategic reserve. From 2020 to 2022, Finland maintained a strategic reserve capacity of 611 MW. However, from July 2022 onward, Finland discontinued its strategic reserve procurement due to the commissioning of the Olkiluoto 3 nuclear power plant and

13. Statnett (2023), Anbefalinger om fremtidens kraftmarked, published 8 December 2023. Available at: statnett.no

updated resource adequacy assessments indicating no need for additional reserves at the time. Finland currently has a strategic reserve measure in place until 2032, but no capacity is contracted[14].

The energy-only market has facilitated the provision of DSR, which is expected to increase significantly. DSR is utilised to address short-term supply and demand mismatches.

Challenges with existing mechanisms

As the existing thermal units gradually retire, the system is becoming increasingly weather-dependent. Firm and flexible capacity is not sufficiently supported given the current market design, as it is expected to operate infrequently, which introduces price and volume risks. Consequently, the business case for such investments is challenging when relying solely on the energy-only market.

2.6 Cost of CRMs in a Nordic context

The financial stakes surrounding capacity mechanisms are significant. ACER reports that annual capacity payments for market-wide CRMs in Europe range from ~€20-60k per MW[15]. Taking these assumptions, covering the Nordic peak demand in 2023 of ~65 GW **would require payments between €1.3–3.9 billion, annually**. In return, one would expect a reduction in the wholesale price level, lower price volatility and a higher security of supply. While these benefits cannot be denied, calculating their magnitude is challenging, whereas the costs are quite evident. If a capacity mechanism is implemented and fails to deliver effectively, consumers or taxpayers ultimately bear the financial burden. Therefore, any mechanism must ensure security of supply in a cost-effective manner. In designing any mechanism, policymakers must have confidence in being able to demonstrate the success of the scheme to prevent political backlash.

Based on ACER's data, the following analysis aims to provide readers with an understanding of the scale of capacity payments. Many factors influence both the volume of MW procured and the cost per MW, meaning this is not a comprehensive cost analysis of potential mechanisms in the Nordic region. Rather, it serves as an illustration of the substantial financial risks associated with implementing mechanisms beyond the energy-only market.

14. ENTSO-E (2023), European Resource Adequacy Assessment 2023 Edition – Annex 4: Country Comments, updated April 2024. Available at: https://www.entsoe.eu/eraa/2023/report/ERAA_2023_Annex_4_Country_Comments.pdf
15. ACER (2023), Security of EU Electricity Supply 2023, European Union Agency for the Cooperation of Energy Regulators, available at: https://acer.europa.eu/sites/default/files/documents/Publications/Security_of_EU_electricity_supply_2023.pdf

Furthermore, this analysis relies on European statistics rather than detailed modelling, which would provide a more precise picture. Modelling is also the only way to account for the benefits of capacity mechanisms, such as lower wholesale prices. The aim, therefore, is not to pinpoint one exact figure, but rather to offer a general understanding of the cost landscape.

Great Britain is not included in this overview, as it is no longer part of the EU and therefore not included in ACER's study. Belgium is also excluded, as its first capacity auction took place in 2021 for the delivery year 2025–2026, meaning relevant data is not yet available in the statistics.

2.6.1 Difference between market-wide CRM and strategic reserve

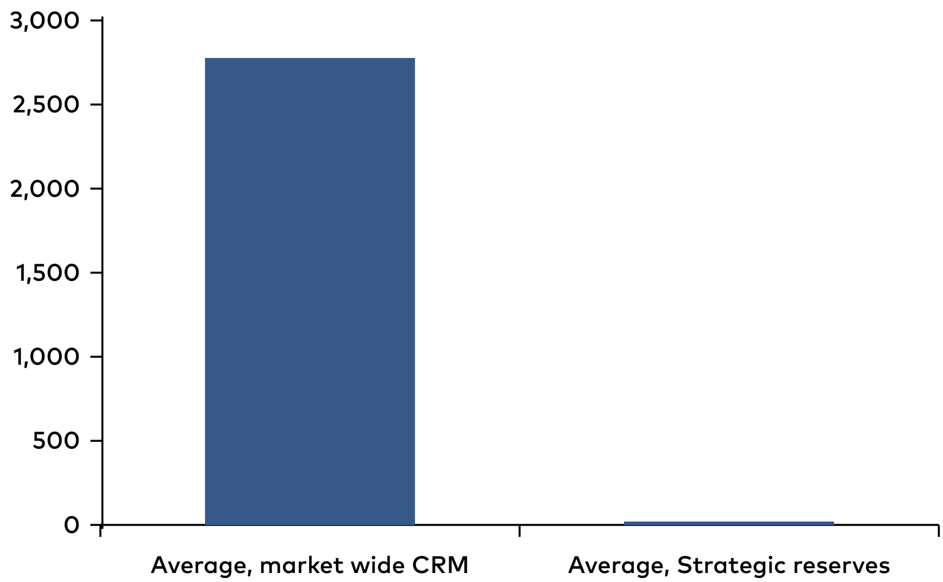
Market-wide CRM and strategic reserve operate under fundamentally different principles, making a direct comparison of their total capacity procurement costs somewhat misleading. Market-wide CRMs are designed not only to ensure resource adequacy but also to drive down wholesale electricity prices, which helps justify their higher costs. In contrast, strategic reserves are targeted at paying only for the additional capacity required, intervening only when needed, leading to significantly lower procurement costs.

To illustrate the financial implications of these mechanisms, it is useful to compare them. As seen in Exhibit 2.7, compensating the entire market under a market-wide CRM require substantial financial commitments, whereas payments for Strategic Reserves appear minimal in comparison. In this graph, the market-wide CRM costs are scaled to reflect the total Nordic peak demand in 2023, while the strategic reserves costs are standardised to a capacity of 600 MW.

This reflects the broader coverage, which inherently require larger payments, while strategic reserves function as a last-resort measure, minimising overall expenditure.

Exhibit 2.7 – Average cost of market-wide and strategic reserves, scaled (million euros)

The graph illustrates that compensating the entire market under a market-wide CRM require substantial financial commitments, whereas payments for strategic reserves appear minimal in comparison.



Notes: This graph compares the average costs of market-wide CRM and strategic reserves, expressed in million euros. The market-wide CRM costs are scaled to reflect the total Nordic peak demand in 2023, while the strategic reserves costs are standardised to a capacity of 600 MW. The data is based on historical records from 2020 to 2024 from ACER.

Source: ACER.

2.6.2 Cost per MW

Exhibit 2.8 presents the cost per MW, providing a basis for assessing efficiency to some extent. However, it is crucial to recognise the fundamental differences between market-wide and targeted mechanisms. In this context, the mechanisms in Germany (DE), Sweden (SE), and Finland (FI) involve targeted payments, resulting in significantly lower overall costs when considering the total MW procured. By contrast, market-wide mechanisms require substantially larger procurement volumes, leading to higher costs.

The costs of Sweden's and Finland's strategic reserves have remained relatively low, even on a per-MW basis. Both countries have successfully maintained older fossil fuel power plants in operation at comparatively low costs. Notably, Finland's strategic reserve costs for 2023 and 2024 are zero, as no reserves were procured during this period.

In contrast, Germany's strategic reserve had a higher cost per MW due to its reliance on more expensive resources, including newer or less depreciated power plants.

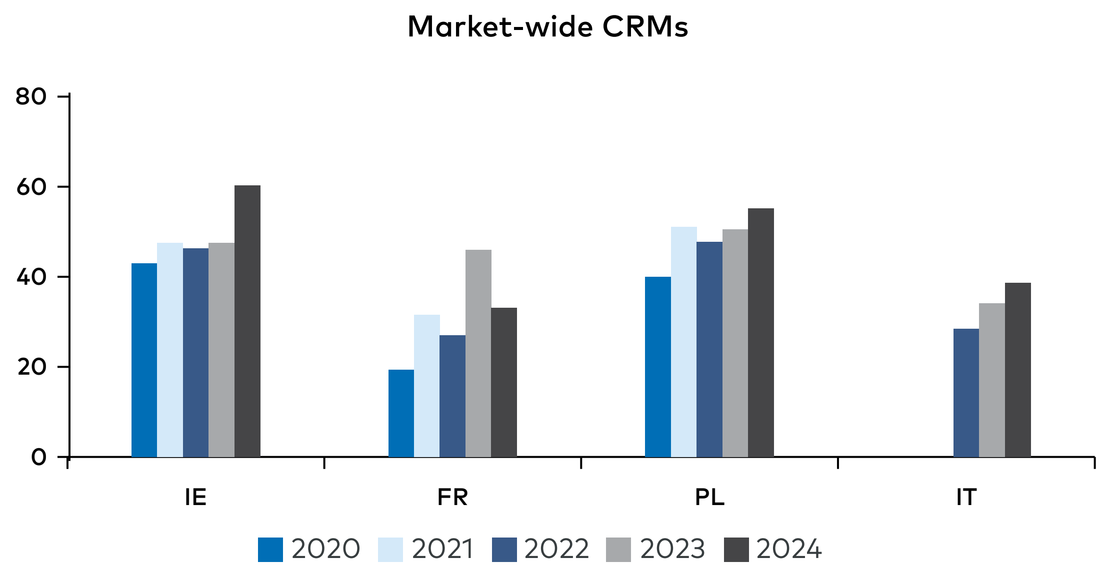
There is also a visible variation in costs between market-wide CRMs over the period shown in the graph. The average annual costs were as follows:

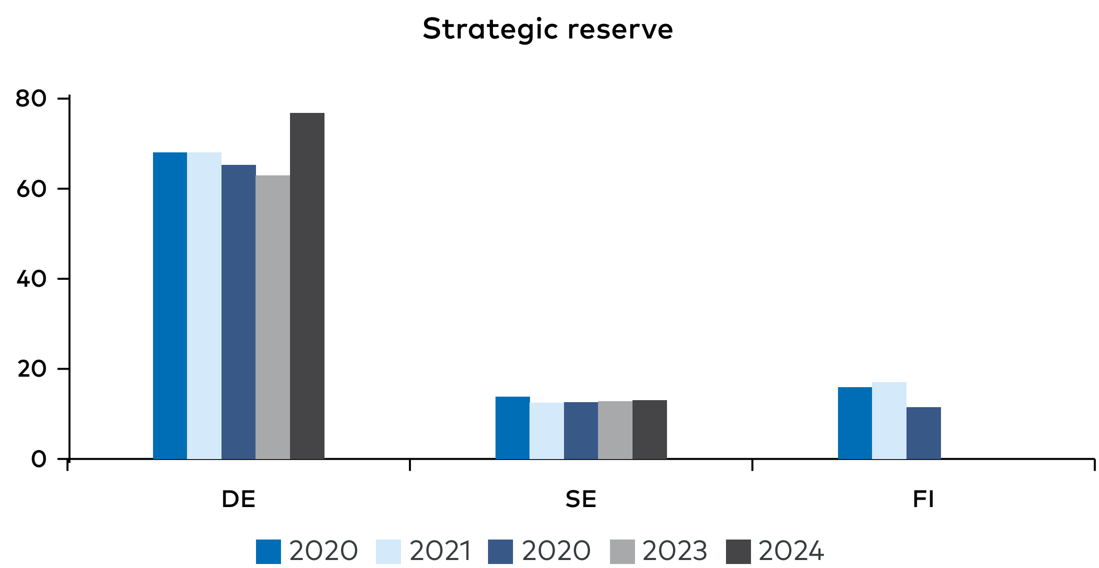
- Ireland: €48.9k/MW
- France: €31.4k/MW
- Poland: €48.9k/MW
- Italy: €33.7k/MW

The variations in costs per MW between different market-wide CRMs can be attributed to differences in design and implementation across each country. Factors such as auction formats, price caps, and the specific requirements of each CRM play a key role for overall costs. Additionally, fundamental differences in the cost of existing and new resources further contribute to the disparities in costs per MW observed.

Exhibit 2.8 – Costs of CRMs per MW of total procured capacity (2020–2024, thousand euros/MW)

Market-wide mechanisms require substantially larger procurement volumes, leading to higher costs, than targeted mechanisms like strategic reserves





IE: Ireland (centralised reliability option)
FR: France (decentralised availability obligation)
PL: Poland (centralised availability obligation)
IT: Italy (centralised reliability option)
DE: Germany (strategic reserve)
SE: Sweden (strategic reserve)
FI: Finland (strategic reserve)
Source: ACER

2.6.3 Cost of market-wide mechanism to meet Nordic peak demand

To contextualise the potential impacts of market-wide CRMs, historical CRM costs from various markets are examined and scaled to a Nordic context that show the cost of covering the 2023 peak demand of each country[16]. Using this approach, the estimated annual average capacity payments across the period and various mechanisms for each country would be:

Finland:
€326.9 million

Sweden:
€594.5 million

Denmark:
€155.8 million

Norway:
€570.4 million

Annex B contains more comprehensive insights, showing the scaled data for each market and over the four-year periods.

2.7 Who can deliver capacity and flexibility?

2.7.1 Technical capabilities

Ensuring a secure, flexible, and decarbonised electricity system requires a diverse mix of technologies, each contributing distinct capabilities across different time-frames. The ability to provide real-time balancing, within-day flexibility, multi-day resilience, and seasonal storage (as defined in Chapter 2.5.1) varies significantly between technologies, shaping their role in maintaining system security and reliability. Ultimately, the key question is whether the energy-only market can deliver the right combination of capabilities on its own or if an additional mechanism is needed to guide development in a specific direction to address potential gaps.

This section presents an overview of the capabilities offered by various technologies, supporting informed decision-making on which solutions to prioritise in addressing future adequacy and flexibility challenges. To facilitate this analysis, two key exhibits are included:

- **A capability table** summarising the role of each technology in delivering flexibility across different timeframes (Exhibit 2.9).

16. Source: Entso-E, Danish Energy Agency, NVE, Finnish Energy, Svenska Kratnät.

- **A time-to-market table** outlining deployment timelines, essential when designing a potential mechanism since it gives indication on required lead-time and frequency of procurement (Exhibit 2.10).

For clarity and analytical structure, technologies are categorised based on functionality and flexibility potential. These categories comprise dispatchable generation, intermittent renewable energy sources, short- to long-duration storage, DSR, and grid infrastructure. A detailed description of each category is provided in Annex C.

Exhibit 2.9 – Technology capability table

A summary of each technology's role in delivering flexibility across different timeframes

Category level #2	Technology	Maturity	Solves capacity (MW) or energy (MWh)?	Capabilities				Non-fossil
Category level #1: Generation technologies								
Dispatchable power plants w/storage capability	Hydropower (with reservoir)	Mature	MW[1], MWh[2]	Real-time	Within-day	Multi-day	Seasonal	Yes
	Pumped hydro storage	Mature	MW[1], MWh[2]	Real-time	Within-day	Multi-day	Seasonal	Yes
	Bioenergy (biomass, biogas, biofuels)	Mature	MW[3], MWh[4]		Within-day	Multi-day	Seasonal	Yes
	Gas-fired power plants (natural gas)	Mature	MW[3], MW[4]	Real-time	Within-day	Multi-day	Seasonal	No
	Gas-fired power plants (hydrogen, biogas)	Mature	MW[3], MWh[4]	Real-time	Within-day	Multi-day	Seasonal	Yes
	Nuclear power	Mature	MW[5]		Within-day	Multi-day		Yes
Dispatchable power plants	Hydropower (run-of-river)	Mature	MW	Real-time	Within-day			Yes
	Geothermal power	Mature	MW[5]		Within-day	Multi-day		Yes
Intermittent RES	Onshore wind	Mature	MW					Yes
	Offshore wind	Mature	MW					Yes
	Solar PV	Mature	MW					Yes
Category level #2: Energy storage technologies								
Short-duration storage	Lithium-ion batteries	Mature	MW, MWh	Real-time	Within-day			Yes
Medium-to long duration storage	Flow batteries	Emerging	MWh		Within-day	Multi-day		Yes
	Sodium-Sulphur (NaS) batteries	Mature	MWh		Within-day	Multi-day		Yes
	Liquid metal batteries	Emerging	MWh		Within-day	Multi-day		Yes
	Iron-air batteries	Emerging	MWh			Multi-day		Yes

	Zinc-air batteries	Develo-ping	MWh			Multi-day		Yes
Long-duration and seasonal storage	Compressed air energy storage	Mature	MWh			Multi-day	Seasonal	Yes
	Hydrogen storage (power-to-gas-to-power)	Emerging	MWh			Multi-day	Seasonal	Yes
	Thermal Energy Storage (TES) (stores excess energy in the form of heat or cold and releases it when needed)	Mature	MWh			Multi-day	Seasonal	Yes
Category level #3: DSR								
DSR	Industrial DSR (flexible factories, cold storage, electrolysis shutdowns, etc.)	Mature	MW	Real-time	Within-day	Multi-day		Yes
DSR	Households demand response (smart appliances, heating/cooling loads, etc.)	Mature	MW	Real-time	Within-day			Yes
DSR with storage	Electric vehicles with vehicle-to-grid capability	Mature	MW, MWh	Real-time	Within-day			Yes
DSR with storage	Electrified district heating (with TES or alternative fuels as backup)	Mature	MW[6], MWh[7]		Within-day	Multi-day	Seasonal	Yes
Category level #4: Grid infrastructure								
Grid infrastructure	HVDC Interconnectors (cross-border energy sharing)	Mature	MW	Real-time	Within-day	Multi-day	Seasonal	Yes
Grid infrastructure	Enhanced distribution networks (smart grids, reinforced transmission lines, digitalisation)	Mature	MW	Real-time	Within-day	Multi-day		Yes

Note: Annex C provides additional information about each technology category
Source: AFRY.

1 turbine upgrade
2 reservoir expansion
3 generator upgrade
4 fuel availability
5 plant upgrade
6 heat pump upgrade
7 TES expansion

2.7.2 Time to market

Capacity and flexibility mechanisms aim to ensure that sufficient resources are available to meet system demand at all times. However, different technologies have vastly different lead-times, which must be considered when designing incentives and procurement timelines:

- **Short-term**: Technologies with short lead-times, such as DSR and battery storage, can be deployed rapidly to fill immediate capacity gaps.
- **Medium-term**: Technologies with moderate lead-times, such as hydrogen electrolysers, require careful planning to ensure they are available when needed.
- **Long-term**: Large-scale infrastructure projects, such as nuclear power plants, new hydropower power plants, or new technologies that need to mature to become feasible solutions, have extended lead-times and require long-term policy certainty to attract investment.

If lead-times are not properly accounted for, a capacity mechanism or flexibility support scheme may fail to deliver the right resources when they are needed, potentially resulting in supply shortfalls or inefficient over procurement.

Exhibit 2.10 below summarises the estimated lead-times for key technologies supporting system adequacy and flexibility. These estimates encompass the time required for project development, permitting, construction, and commissioning, though actual durations may vary depending on regulatory frameworks, grid connection availability, and supply chain constraints. Most of the data is sourced from the IEA's Energy Technology Perspectives report (2023) and similar studies. However, conditions in the Nordic region may differ, and a region-specific analysis is recommended to ensure more accurate assessments.

Exhibit 2.10 – A time-to-market (build time) table

Deployment timelines, crucial for assessing short- and long-term investment needs

Technology	Lead-time (years)	Key considerations
Hydro power w/ reservoir	5-10	The 5-10 years timeline reflects long permitting processes, environmental impact studies, and the complex engineering needed for hydropower facilities.
Hydro power w/ pumped storage	6-12	Pumped hydro storage typically takes 6-12 years due to site-specific geographic requirements, long permitting processes, and high capital costs for infrastructure.
Gas power plant (CHP, CCGT & OCGT)	2-5	The lead-times for gas power plants are primarily driven by regulatory approvals, complex design requirements, and supply chain dependencies for specialized equipment.
Biomass / biogas power plants	2-9	Lead-times of 2-9 years are associated with the size of the plant, permitting, construction, and supply chain setup for biofuels, especially ensuring sustainability and compliance with regulations.
DSR (households & EV)	0.5-2	The 0.5-2 years lead-time is based on the setup of necessary technology, consumer agreements, and regulatory processes. This asset requires minimal construction but more focus on agreements and technology readiness.
DSR (industry)	0.5-2	The lead-time of 0.5-2 years for demand-side response in industry is primarily determined by the deployment of necessary technology, the establishment of agreements with industrial participants, and navigating regulatory requirements
Batteries	1-3	Lead-times of 1-3 years are based on the shorter construction and installation period for battery systems, along with the need for grid integration and permitting. Studies suggest BESS can be installed quickly compared to other assets, typically within 1-3 years.
E-fuels & H2 (X2P)	4-8	In the case of hydrogen lead-times of 4-8 years are common due to the development of electrolysers, storage facilities, and infrastructure.
Thermal energy storage	2-5	Typically installed within 2-5 years, depending on system integration with existing heating and cooling networks, and the complexity of installation.
Grid capacity/ICs	8-12	The 8–12 years lead-time for grid upgrades results from extensive planning, permitting, and construction, compounded by stakeholder engagement, supply chain constraints, and integration challenges.
El. boilers/heat-pumps (w/ alternative fuels)	1-3	Expanding heat pump manufacturing typically takes 1–3 years, leveraging modular production and existing air-conditioning technology.

Sources: IEA (2023) "Energy Technology Perspectives 2023", UK Power Networks (2021) "DSR Flexibility Service Guide", IEA (2019) "Average power generation construction time", eFuel Alliance "eFuels production map".


↑ Photos: iStock

3. Design objectives

Design objectives work as a guidance for designing market mechanisms and a framework for evaluation of performance of the mechanisms. This chapter describe the primary and secondary objectives for a Nordic design, including constraints.

To guide the market design process, a structured framework of design objectives and constraints has been developed.

Primary objectives define the overarching vision for an effective market design, focusing on the desired end-state without being constrained by physical limitations.

Secondary objectives provide context by addressing key questions:

- What must the market deliver to achieve the primary objectives?
- Are there factors that, while not defining ultimate success, are still crucial to consider?

Design constraints, whether physical, regulatory, or policy-driven, set the boundaries within which the mechanism can be designed.

Exhibit 3.1 below provide a high-level overview of the design objectives. A more detailed description of each objective can be found in Annex A.

Exhibit 3.1 – Design objectives overview

Market objectives work as a guidance for designing markets and a framework for evaluation of market design performance

PRIMARY OBJECTIVES	SECONDARY OBJECTIVES	CONSTRAINS
Cost efficient provision by; minimising overall system cost; promote efficient use of resources; avoid over-procurement and market distortion	**Practical** • Ease of implementation • Simplicity in market participation • Ease of ongoing operation	**Market-based**
Maintain system security by; securing adequate capacity; complying with reliability standards; and incentivising investment in reliable & flexible resources	**Investable** • Respecting existing investments • Supporting efficient future investments – sufficient incentives	**EU regulatory compliance**
Support a zero-carbon system, by; promoting low-carbon technologies; and incentivising flexibility	**Transparent** • Visibility of TSO needs, bids & results • Clear procurement decisions • Broadly understood mechanism	**Targeting new investments (NFFSS)**
	Enduring (stable) • Suitable/adaptable to future challenges • Well understood governance for changes	**Non-fossil (NFFSS)**
	Limit negative cross-border impact • Limit market distortion on neighbouring markets • Fair distribution of payments	**Facilitate cross-border participation (CRM)**

Note: The objectives were created by AFRY and agreed within the project group as a set of guidelines for the project.
Source: AFRY.

3.1 Primary objectives: The energy trilemma

The energy trilemma arises from the challenge of balancing the following three key objectives simultaneously:

- **Cost efficient provision:** Ensuring that electricity markets operate competitively, minimising costs for consumers and avoiding excessive subsidies or distortions.
- **Maintain system security:** Guaranteeing that electricity is available when needed, even during peak demand or supply shocks, by incentivising adequate investment in reliable capacity.
- **Support a zero-carbon system:** Structuring the market to support decarbonisation, encouraging investment in renewables, energy storage, and low-carbon flexibility solutions.

These objectives can often be in conflict:

- **Cost efficiency vs. security of supply:** A purely market-driven approach may lead to underinvestment in firm capacity, increasing the risk of blackouts. On the other hand, capacity mechanisms that ensure reliability can add costs and distort price signals.
- **Cost efficiency vs. zero-carbon:** A technology-neutral market may favour fossil fuel generation in the short term due to their established infrastructure and lower marginal costs, but direct support for renewables can distort competition and increase system costs.
- **Security of supply vs. zero-carbon:** Fossil fuels have historically provided stable generation but phasing them out too quickly without sufficient low-carbon flexibility (e.g., storage, DSR) could compromise grid stability.

Addressing the trilemma requires careful design of solutions. Ultimately, no single design perfectly resolves the trilemma, so policymakers must strike a balance that evolves with technology, system needs, and policy priorities.

3.2 Secondary objectives

The secondary objectives serve as guiding principles to ensure the proposed market design is not only effective in addressing the missing money problem but also viable in practice. These objectives help balance economic, regulatory, and operational considerations, supporting a well-functioning market:

- **Practical:** The proposed mechanism must be feasible to implement, avoiding unnecessary complexity that could hinder adoption or effectiveness. It must also be practical to operate.

- **Transparent:** Clear and predictable rules enhance trust among market participants, reduce regulatory uncertainty, and improve decision-making for investors and policymakers.
- **Investable:** A stable and predictable framework is essential to attract long-term investment in flexible and low-carbon capacity, ensuring security of supply. A solution must also respect existing investments.
- **Enduring**: The design should be robust to future changes in technology, policy, and market conditions, minimising the need for frequent revisions.
- **Limit negative cross-border impact:** To maintain market efficiency and fairness, the design must avoid unintended distortions in neighbouring markets and ensure a fair distribution of costs and benefits.

Further details on each objective are provided in Annex A.

3.3 Design constraints

The design constraints ensure that the proposed market mechanism operates within clear boundaries, aligning with policy goals, regulatory frameworks, and practical implementation considerations. These constraints help shape a solution that is both effective and compliant with broader energy market principles:

- **Market-based:** The design should leverage competitive market principles to ensure cost efficiency, minimise distortions, and allow price signals to drive investment and operational decisions.
- **EU regulatory compliant:** The mechanism must align with EU state aid and electricity market regulations to ensure the design is approved by the EU commission.
- **Targeting new investments** (NFFSS only): The mechanism should primarily support the development of new flexible capacity rather than subsidising existing assets.
- **Non-fossil** (NFFSS only): Given the design principles in the NFFSS regulation, the design should focus on supporting low-carbon or zero-emission flexibility solutions.
- **Facilitate cross-border participation** (market-wide CRM only[17]): Given the regulation of CRMs, the design should enable participation from assets in neighbouring countries where possible, improving efficiency and security of supply across borders.

Further details on each constraint are provided in Annex A.

17. Targeted schemes may deviate from this requirement, if it is established that cross-border solutions does not solve the adequacy concern.

↑ Photos: iStock

4. Key design elements and considerations

This chapter examines the fundamental building blocks that constitute the design of capacity mechanisms and flexibility support schemes. By examining these key design elements and considerations, it provides a comprehensive understanding of the various components that must be integrated to create an effective and efficient mechanism. This is laying the groundwork for the subsequent chapters, where solutions are evaluated and potential design alternatives are shortlisted for the Nordic market. Building on the market background provided in Chapter 2 and the design objectives outlined in Chapter 3 this chapter serves as a bridge to the detailed analysis and comparison of capacity mechanisms in the following chapters.

4.1 Summary

In the design and analysis of different market configurations, design alternatives are decomposed into smaller building blocks, enabling a systematic examination of each element both individually and in combination. This method provides a structured framework for comparing various design choices and evaluating their respective impacts.

This report distinguishes between first order and second order building blocks. First-order building blocks represent the core design parameters that define the fundamental functioning of the overall mechanism. In contrast, second-order building blocks are more flexible elements that can be adjusted or modified independently of the overarching market design.

4.2 First order building blocks

In total five first order building blocks are identified, as shown in Exhibit 4.1. These building blocks are elaborated in the following chapters and represents the most important, overarching design choices that need consideration when implementing a mechanism.

Exhibit 4.1 – First order building blocks for designing a capacity or flexibility mechanism
The first order building blocks represent the key choices that must be considered when designing a capacity or flexibility mechanism

Determining and securing volume	On what basis is the overall volume requirement set, and who secures it?
Market-wide vs targeted	Should the whole market or only a selection of the market receive support?
Eligibility	Who can participate and how to rate their expected performance?
Product obligations	What commitments will providers need to make?
Recovery scheme	How is cost recovered and from whom?

Source: AFRY.

There is a wide range of potential combinations of design building blocks, which can be categorised in several ways. A natural and fundamental distinction lies between market-wide and targeted mechanisms, two conceptually different approaches that are examined in detail in this report.

To add another perspective, these design choices can also be grouped into three overarching categories: Investment Support, Availability Obligations, and Options. Exhibit 4.2 and the accompanying text illustrate how different variants within these categories can be developed, broadly ordered from the simplest to the most complex:

Investment support: Under this model, the provider is required to build new capacity but is not obliged to offer this capacity into any specific market. The focus is solely on the upfront investment.

Availability obligation (or physical commitments): The provider must make capacity available to the market or the TSO. This obligation can be structured in different ways, depending on who procures the capacity:

- Centralised: Procured by the Transmission System Operator (TSO).
- Decentralised: Procured by retailers or large consumers.
- Hybrid: A mixed model where, for example, the TSO secures long-term commitments while retailers procure capacity in the short term

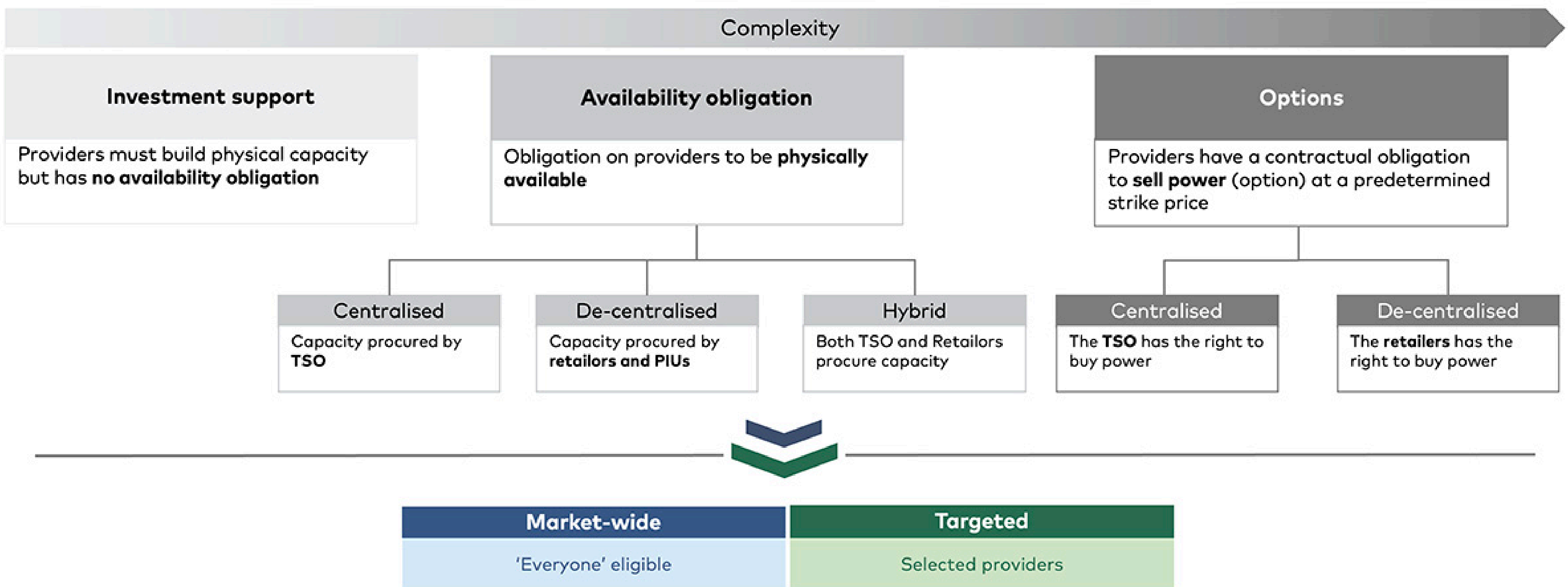
Options: These typically involve both a financial and a physical commitment through an option contract. The provider must compensate the buyer financially when the reference price exceeds a predefined strike price. Procurement of such options can occur:

- Centralised: The TSO holds the right to purchase electricity at the strike price.
- Decentralised: Retailers or large consumers hold this right, effectively using the option as insurance against high market prices.

The designs can then be categorised as either market-wide or targeted schemes. Following this, decisions must be made regarding the recovery scheme and eligibility criteria. Ultimately, all the first order building blocks are closely interconnected, and some combinations naturally follow from others decisions to form coherent and viable high-level design options.

Exhibit 4.2 – Overarching design alternatives for capacity or flexibility mechanisms

Direct investments support is the simplest mechanism, while a de-centralised option design would be the most complex – most designs could be either targeted or market-wide, with some exceptions



Note: Power Intensive Users (PIUs), i.e. large consumers of electricity.
Source: AFRY.

All the first order building blocks are elaborated in the following sub-chapters.

4.2.1 Determining and securing volume

The overall volume required to be procured by the mechanism is determined based on a needs assessment, however, different approaches exist for securing it. There are two primary models: centralised and decentralised, or a combination of both:

- **Fully centralised**: In a fully centralised market, a central authority, such as the TSO, is responsible for organising the procurement process. The central authority is contracting with providers to ensure system reliability. Centralised models provide greater oversight and coordination.
- **Fully decentralised**: In contrast, fully decentralised markets place the responsibility on individual market participants, such as retailers and PIUs or flexibility providers. These entities negotiate contracts directly based on their own assessments of future needs. Decentralised models offer greater flexibility, allowing participants to leverage their in-house knowledge, which can foster innovation and more tailored solutions. In a decentralised market, market participants are typically incentivised to secure volumes as they otherwise risk the exposure to price spike.
- **Hybrid**: Alternatively, a centralised authority may determine the volume that each market participant needs to procure.

4.2.2 Market-wide vs targeted

Capacity and flexibility mechanisms provide financial incentives to providers, encouraging them to invest in and maintain the necessary resources. There are two primary types of mechanisms: market-wide and targeted. Each approach has its own advantages and is suited to different market conditions and policy objectives.

- **Market-wide** mechanisms are designed to ensure that all capacity required to maintain system reliability receives payment. This approach includes both existing and new capacity providers. It aims to provide a comprehensive solution to resource adequacy and to promote competition among a wide range of providers.
- **Targeted** mechanisms focus on specific types of capacity or particular segments of the market. These mechanisms are designed to address specific needs or gaps in the electricity supply, such as incentivising the development of renewable energy sources or ensuring the availability of peaking power plants. By concentrating on particular resources, targeted mechanisms can provide tailored solutions to specific challenges within the electricity market.

When support is provided only to a subset of market participants, it can depress market prices for all, resulting in financial losses for those not receiving support. In contrast, under a market-wide mechanism, all providers are compensated for the reduction in market prices, with the intention that they achieve the same return as they would in the absence of the capacity mechanism. For end consumers, this typically translates into lower wholesale electricity prices, but higher fixed charges, through taxes or grid fees paid to the TSO, to fund the mechanism. Targeted schemes generally require significantly lower overall payments, as they do not involve compensating the entire market. However, such schemes can result in financial losses for those excluded from support, particularly if the supported assets are not ringfenced from market participation. This may lead to a crowding-out effect, where unsupported providers are gradually driven out of the market due to reduced revenues.

4.2.3 Eligibility

A critical component of effective mechanisms is the establishment of clear and robust eligibility criteria. These criteria determine which resources can participate in the capacity or flexibility mechanism and are vital for several reasons.

Firstly, eligibility criteria are fundamental in ensuring resource adequacy. By setting stringent requirements, policymakers can guarantee that only reliable and capable resources are included. This is crucial for supporting the technology that is needed to solve the identified resource adequate need.

Secondly, eligibility criteria contribute to the cost-effectiveness of capacity mechanisms. By excluding, or derating (see below), "inefficient" resources, these criteria help to minimise costs by preventing unnecessary financial burdens on consumers and for maintaining the overall efficiency of the electricity market.

Thirdly, eligibility criteria play a crucial role in maintaining market integrity. By ensuring that only the needed capacity is rewarded, these criteria prevent undue distortion to the market where all market participants operate on a level playing field.

Derating factors adjust the nominal capacity of different resources to reflect their expected availability to solve the resource adequacy problem identified, and is an important concept in all capacity mechanisms. For example, 1 MW of wind power would not receive the same support as 1 MW of nuclear capacity due to differences in reliability and availability, or in other words, how firm the capacity is considered. These factors ensure that the mechanism accurately represents the true contribution of each resource to system reliability.

However, too strict eligibility criteria would risk excluding relevant providers. On one hand, when determining the eligibility criteria one must strive for technology-neutral and encourage innovation (in other words, taking into account potentially new technologies and/or evolution of existing technologies) and on the other hand making sure that the procured assets actually solve the problem identified. To support this balance, the concept of fixed and dynamic eligibility is introduced:

Fixed eligibility refers to the application of absolute minimum requirements that must be fulfilled in order to participate. This concept is well established in, for example, ancillary service markets, where technical minimum standards must be met as a condition for entry. The eligibility criteria can also be designed to target specific asset types, such as exclusively new, non-fossil assets, within a particular bidding zone or geographic location.

Dynamic eligibility entails that the assets must meet a lower minimum requirement, but the quality of the service impacts the selection process (i.e. which providers are successful in the procurement process). The minimum requirement could for example be new, non-fossil assets. In the next stage, based on the needs assessment, one defines performance standards and associated derating factors. Some examples are:

- A locational derating factor could be applied to facture in likely effectiveness of solving the problem. As a simplified example, if grid capacity between area (a) and area (b) is expected to be congested 85% of the time, then a provider located in area (b) would have limited ability to resolve an issue in area (a), and should therefore be assigned a derating factor of, for example, 15%. A reliability derating factor could be applied to reflect that certain technologies contribute less to system adequacy due to their lower reliability.
- A ramping speed derating factor could be used to promote fast response over technologies with a slower response.
- A response duration derating factor could promote providers that can continuously operate for a longer period without interruption, if this is necessary to solve the problem identified.

4.2.4 Product obligation

This building block examines the nature of the product being procured, focusing on the commitments required from providers. The key question is: what obligations must providers fulfil? While the product obligation can take different forms, it must ultimately ensure clear commitments to guarantee reliable service throughout the contract period and support the evolving needs of the energy system.

Investment support:

- **No availability obligation**: Contracted units receive an annual payment, throughout the contract period. The units are free to operate in the wholesale market. While there is no direct availability obligation, they are indirectly required to participate in the market under the REMIT regulation[18] or corresponding national regulations.

Physical commitments, where the provider must provide physical capacity:

- **Availability obligation**: Providers receive capacity payment solely for availability, with no additional compensation for activation, as they earn revenues from participating in the wholesale energy market. They are required to ensure the awarded capacity is available when called upon but are otherwise free to operate in the market.
- **Service-specific availability obligation**: Providers receive capacity payment solely for availability but are required to participate in a specific market, such as the SDAC market or the aFRR/mFRR EAM. Awarded participants may generate further revenue through the participation in the respective market if their bids are activated.
- **Ring-fenced**: Providers receive capacity payment solely for availability but must ensure firm availability with a high expectation of reliability throughout the contract period. Capacity is ring-fenced from the market and awaits dispatch instructions from the TSO. Units does not typically earn revenues from participating in the wholesale energy market, but activations are compensated by a cost-based payment.

Financial commitment, where the provider must financially compensate the buyer:

- **Reliability option**: Providers receive capacity payment solely for availability, in form of issuing an option based on their physical capacity, and can offer the awarded capacity in the market. However, they must pay a 'difference' charge if the market price exceeds a predefined strike price to the buyer of the option.

4.2.5 Recovery scheme

The costs of the capacity or flexibility mechanism must be recovered from somewhere. There are several viable alternatives for determining who should bear these costs and how payments can be recovered.

Some cost recovery schemes may incentivise more efficient grid usage by charging higher fees to those who contribute most to peak load. This approach promotes fairness by aligning costs with usage, encouraging consumers to reduce their demand during peak periods and thus contributing to overall grid efficiency.

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18. European Union (2011), Regulation (EU) No 1227/2011 of the European Parliament and of the Council of 25 October 2011 on wholesale energy market integrity and transparency (REMIT), Official Journal of the European Union, L 326, 8.12.2011, Art. 1–20. Available at: https://eur-lex.europa.eu/eli/reg/2011/1227/oj

In contrast, the cost burden could be distributed more evenly across all users, ensuring broad societal participation in funding security of supply. This approach treats reliable energy supply as a public good, recognising that everyone benefits from a stable and secure electricity system.

The relevant variants are:

- **Retailors and Power Intensive Users (PIUs):** In a decentralised capacity mechanism, the responsibility of procurement and cost falls on the users of electricity directly. One could also require that the retailors charge a fixed fee to the end-user, similar to the Norwegian-Swedish electricity certificates system, to finance the capacity mechanism.
- **TSO:** Costs are socialised and borne by the TSO, who recovers them through regulated grid tariffs or via other means. This could either be done by;
    - **Targeting peak consumption** (a kW-based surcharge), where different consumer segments are charged for the energy used during specific pre-defined high load periods. These periods can vary by season, day type, and time of day, reflecting when system demand and adequacy risks are highest; or
    - **Non-targeted** (kWh-based surcharge), where cost is socialised across all network users.
- **Taxpayer:** The cost of the mechanism may also be funded directly from the state.

The above alternatives can also be combined with a **clawback mechanism**. A clawback mechanism is essentially a profit-sharing arrangement designed to ensure that if an asset becomes highly profitable, the benefits are shared with those funding the mechanism. When the provider's market revenues exceed a certain threshold, the clawback mechanism kicks in, allowing the capacity mechanism funders to reclaim a portion of the excess profits. This is typically done by comparing the provider's market revenues to an index that reflects normal market returns across various timeframes. The clawback mechanism should ensure that capacity providers remain motivated to perform efficiently, even after reaching the "profit threshold". In practise this would entail that not 100% of the revenues beyond the threshold is recovered by the funders.

Ultimately, the choice of cost recovery scheme depends on policy objectives, regulatory frameworks, and the specific characteristics of the electricity market. Policymakers must balance the need for efficiency, fairness, and broad societal participation.

4.3 Second order building blocks

In total five second order building blocks are identified, as shown in Exhibit 4.3. These building blocks are elaborated below.

Exhibit 4.3 – Second order building blocks for capacity or flexibility mechanism design

The second order building blocks can be adapted to fit into a range of different capacity mechanism

Contract type & duration	What is the contracted duration and potential coverage periods?
Duration of need & MTU	How long consecutive periods must be covered and what is the shortest practical MTU?
Procurement mechanism	What is the mechanism for buying and selling (trading) the services? How are prices set?
Lead-time and frequency	For how long in advance must volume be secured and how often?
Nature of penalty	What is the penalty for non-delivery?

Note: Market Time Unit (MTU).
Source: AFRY.

4.3.1 Contract type & duration

Duration: The duration of the contracts significantly impacts investment decisions for potential providers. Long term contracts, defined here as ten years or more, can lower the annual cost by spreading the capital expenditure over a longer period, making investments in new build assets more attractive. In contrast, short-term contracts, typically ranging from one to two years, offer improved forecast accuracy. This enables TSOs to better assess their evolving needs, incorporate emerging technologies, and adapt market design elements accordingly. Striking a balance between the financial stability afforded by long-term contracts and the adaptability of short-term arrangements is essential for maximising both investment viability and operational efficiency within a mechanism.

Shape: Energy and flexibility needs vary significantly during the season, weeks and days. A market should seek to minimise over-procurement. Offering shaped contracts could enable the TSO to procure volumes more accurately, if the profile of needs can be predicted. Shaped contracts can also be designed to fit different types of technologies, enabling a broader access to the market. This is illustrated in the following exhibit, showing that Sweden and France exercise shaped contracts, while a range of other countries, including Finland, apply commitments all year around.

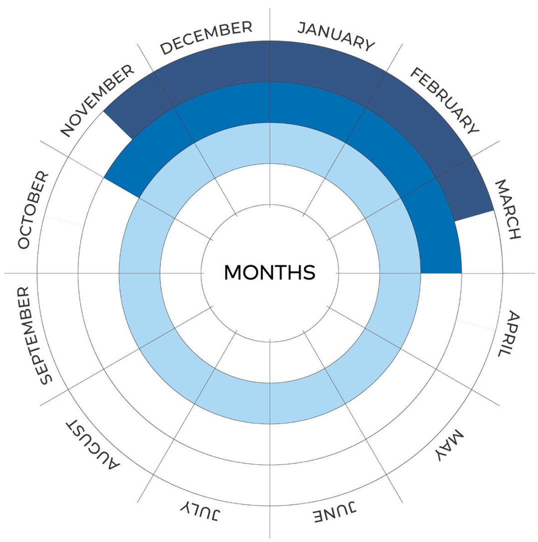


Exhibit 4.4 – Delivery periods for shaped and unshaped contracts
There are examples in Europe of both shaped and unshaped contracts, where Sweden (SE) and France (FR) offer shaped contracts.

- Sweden
- France
- Belgium, Denmark, Finland, Ireland, Italy and Poland

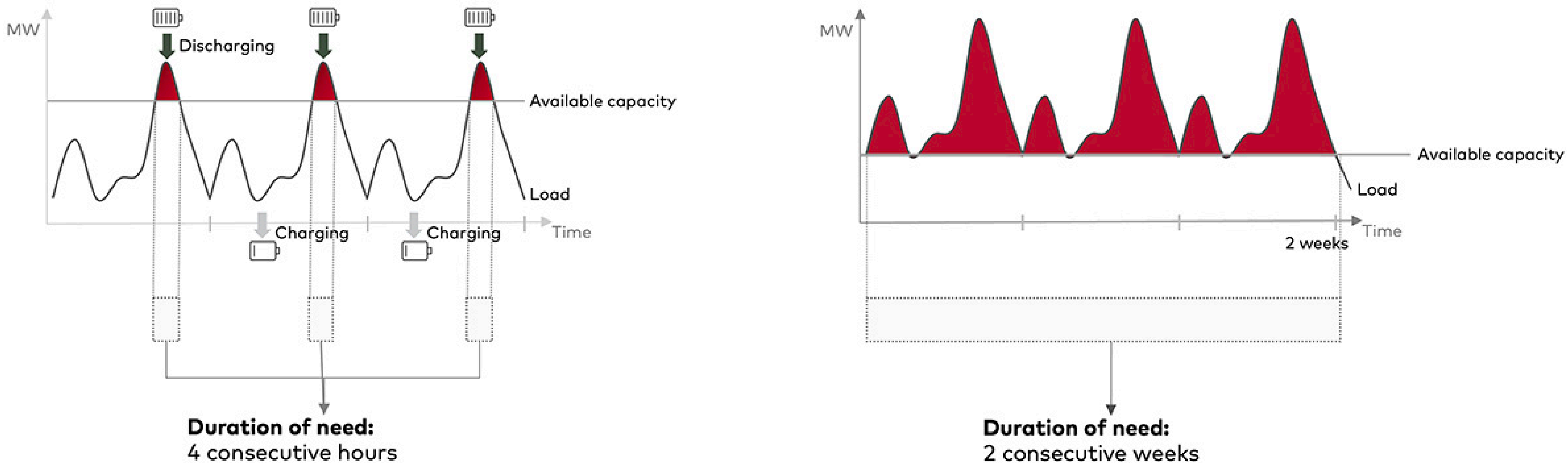
Source: ACER (2023). Security of EU electricity supply 2023. European Union Agency for the Cooperation of Energy Regulators, Figure 13, p. 61.

4.3.2 Duration of need and market time unit (MTU)

While contract duration sets the time of contract obligation, the duration of need describes the duration of consecutive hours expected to be needed during a scarcity event. The duration of need will be set based on the characteristics of problem in the price area and may vary from minutes to weeks. This is illustrated in the below graphs.

Exhibit 4.5 – Examples of 'duration of need'

The consecutive duration of capacity shortages defines the required products and technologies to address the issue effectively



Source: AFRY.

For example, if the duration of need is four hours per day, BESS would manage to discharge over 4 hours and using the remaining 20 hours to charge. In contrast, if the duration is continuously over two weeks, conventional BESS does not have the opportunity to charge and would in this example not be able to contribute in any meaningful way.

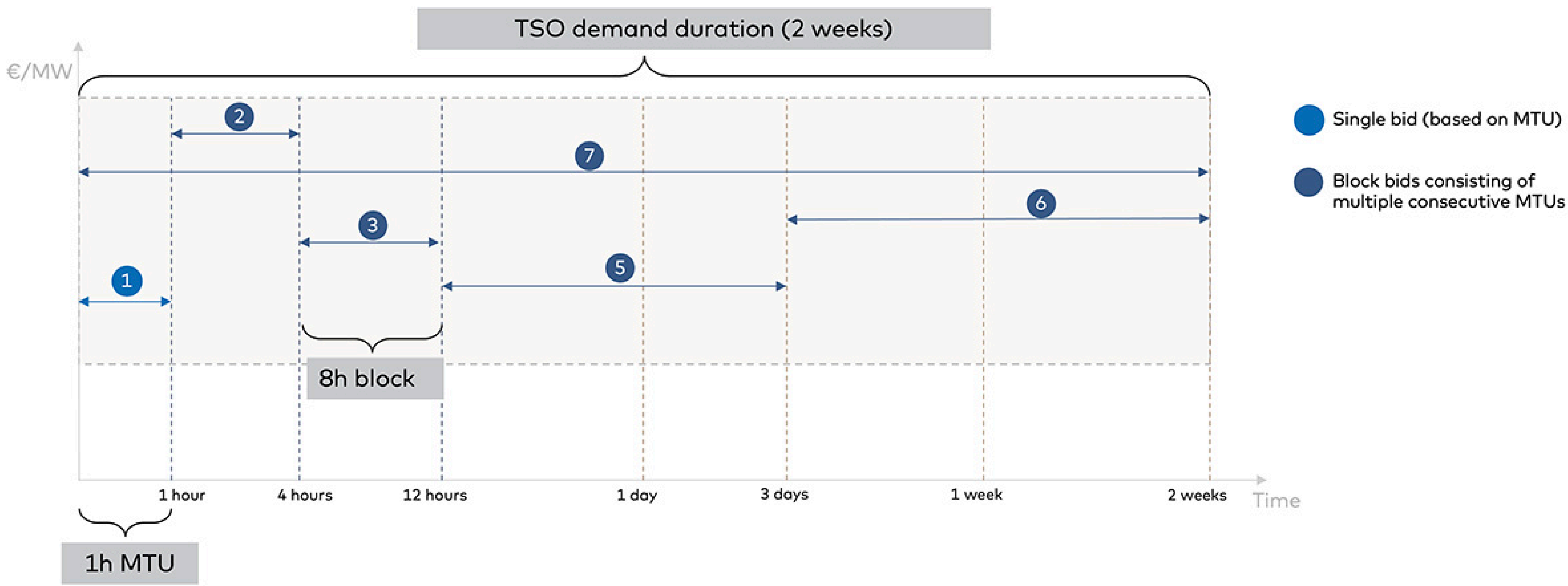
A prolonged scarcity period signals the need for more stable resources capable of delivering over extended durations. However, allowing market participants with shorter delivery periods to contribute could reduce costs. To facilitate this, the duration of need should be subdivided into smaller Market Time Units (MTUs) during the procurement process. Although total duration of need is four days, this does not necessarily mean that every provider must supply capacity continuously for the entire period.

This concept can be contextualised using the Single Day-Ahead Coupling (SDAC) market as an example. In SDAC, only a limited share of generators can provide electricity continuously (baseload), while the market is optimised by combining baseload resources with more flexible assets that help balance variable renewable energy sources (RES) and fluctuations in demand throughout the day.

A similar approach could be applied to a capacity or flexibility mechanism by incorporating SDAC-like order types, such as 'single bids' at MTU, block bids and various other flexible orders, into the procurement process, with an optimisation algorithm selecting the required capacity at the lowest total cost. Exhibit 4.6 illustrates different procurement alternatives: one option is to select bid (7), which can meet the full requirement alone, while another option is to combine bids (1) to (6) at a lower overall cost, despite block (2) being priced higher than block (7) in the given period.

Exhibit 4.6 – Different Market Time Unit (MTU) can lead to different results

A lower MTU allows for broader participation



Source: AFRY.

4.3.3 Procurement mechanism

Auctions and tenders are common methods used to procure the necessary capacity to ensure a reliable electricity supply. These processes involve competitive bidding, where capacity providers submit offers to supply capacity at specified prices. There are also some other variants available as illustrated in Exhibit 4.7.

Exhibit 4.7 – A range of procurement mechanisms are available

Different procurement mechanisms typically have a dedicated price mechanism

AUCTIONS	TENDERS	BILTERAL OTC	CONTINOUS TRADING
A competitive process where buyers and sellers submits bids & offers to the market based on marginal cost & willingness to pay. Prices are formed based on market equilibrium. Commonly used in energy markets to allocate resources efficiently.	A tender process incentivise investment by inviting companies to compete for contracts. Companies submit bids to offer a service or complete a project, and the bids are evaluated based on factors like cost and suitability. The winners receive contracts or financial support, giving them security for their investment.	Direct transactions between two parties without a central exchange. Terms are privately negotiated, providing flexibility in contract conditions. Common in energy markets where bespoke contract terms are important.	Ongoing market activity where contracts are bought and sold continuously over an extended period. Participants can adjust positions over time, taking advantage of price fluctuations.
Price Mechanism: Typically pay-as-clear.	**Price Mechanism:** Typically pay-as-bid'.	**Price Mechanism:** Typically pay-as-bid.	**Price Mechanism:** Typically pay-as-bid.

Source: AFRY.

Bilateral Over The Counter (OTC) and continuous trading is more relevant in a decentralised market with a range of buyers and suppliers, and relatively frequent transactions.

A price mechanism refers to the system by which prices are determined in a market. Buyers and sellers are settled based on the price, which might not be the same as their bidding price. In a pay-as-bid mechanism, each capacity provider is paid the price they bid, which can lead to cost control but may result in complex bidding strategies and reduced transparency. In contrast, a pay-as-cleared mechanism pays all successful providers the same market-clearing price, promoting transparency and efficient bidding, but potentially leading to higher overall costs and windfall profits for some providers.

Pay-as-clear may complicate the ability to select bids based on performance attributes, as these units may not be the marginal units. This could lead to transparency issues, where cheaper bids are excluded, and high-performing units sets a high clearing price. This could be solved by filtering out the 'high-performing units' separately from the marginal pricing calculation.

4.3.4 Lead-time and frequency

Lead-time is the period between procurement and contract start, i.e. when the asset must be ready to deliver services. A sufficient lead-time is crucial for driving long-term investments. It supports both long-term planning and efficient short-term dispatch by providing a clear timeline for when new capacity will be available. Adequate lead-time allows for the development and integration of new resources, ensuring that the market can respond effectively to future demand. Please see overview of lead-times for different technologies in Chapter 2.7.2.

The frequency of procurement determines how often the market is run. Frequent procurement (e.g., annually) can provide regular opportunities for new entrants and adjustments based on updated forecasts, enhancing market responsiveness. Infrequent procurement (e.g., ad-hoc when needed) may reduce administrative costs but can lead to less predictable investment signals.

Depending on the need identified, it is also possible to do a combination. One could for example secure some capacity with short lead-time (potentially also combined with a short contract period), to bridge the gap until the "long lead-time asset" comes online.

4.3.5 Nature of penalty

The nature of penalties describes the consequences of failing to meet obligations. Penalties are essential in any market mechanism or support scheme as they motivate providers to deliver as committed, maintaining system security. They ensure that consumers get the service they pay for by holding providers accountable for non-performance. Penalties should promote fairness and competitiveness in the market and prevent gaming and windfall gains, while at the same time not increasing the risk for potential providers beyond what they can accept. Penalties can range from financial penalties to more severe consequences, such as exclusion from future participation in the market. Several alternatives exist:

- **Non-payment for non-availability**: Capacity providers do not receive their contracted payments if they fail to meet their availability obligations.
- **Administered penalty for non-availability**: A predefined penalty is applied when a capacity provider fails to make their committed capacity available when required, regardless of whether there is a system-wide shortage.
- **Administered penalty during shortage**: A predefined penalty is triggered specifically during a system-wide capacity shortage if a provider fails to deliver their promised capacity during critical periods when the grid is under stress.
- **Exposure to the difference between market price and option strike price**: Capacity providers are exposed to the difference between the market price and the strike price of their option, in addition to an administered penalty, in the event of a shortage.

↑ Photos: iStock and Johnér

5. Longlist of design alternatives

This chapter provides an overview of existing mechanisms, primarily in Europe, as well as theoretical concepts not implemented. The chapter is meant to give a general overview of the different design variants both for CRMs and NFFSS and develop a longlist of design alternatives. This will serve as the basis for the selection of some designs to be explored and assessed in detail in later chapters – the shortlist – to do a deep-dive analysis.

5.1 Summary

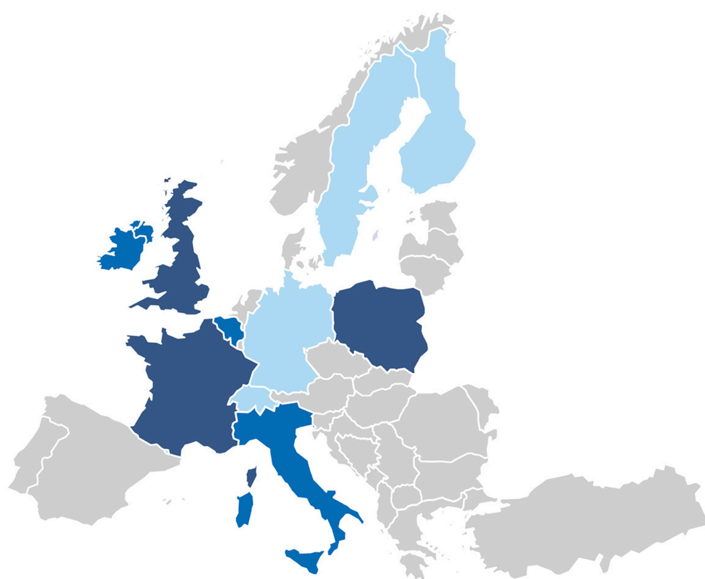
A range of CRMs and flexibility support schemes are already implemented across Europe, with several additional conceptual designs proposed. While no support scheme has yet been implemented under the NFFSS regulation, similar schemes that are likely to fall under its scope in the future have already been approved under state aid rules and are either in operation or under development.

This chapter explore various design alternatives, describing them using the building blocks outlined in Chapter 4. A key takeaway is that all CRMs and flexibility support schemes are different. Each is tailored to the specific needs and circumstances of the country in which it is implemented. The longlist presented here provides the foundation for selecting a subset of designs for more detailed analysis in subsequent chapters—the shortlist—where a deeper evaluation of their relevance and applicability to the Nordic context is undertaken.

5.2 Capacity Remuneration Mechanisms (CRMs)

This sub-chapter explores the various CRMs that have been conceptualised and implemented across Europe. It begins with exploring a longlist of CRMs, encompassing both conceptual models and those that have been practically applied in different markets. By examining existing implementations, it provides insights into the effectiveness and challenges of different CRM designs, setting the stage for identifying the most relevant alternatives for the Nordic market. Exhibit 5.1 shows an overview of current CRMs in Europe.

Exhibit 5.1 – A range of different CRMs exists in Europe today
Different countries have chosen different mechanisms to deal with adequacy issues, but most markets operate on an energy-only basis



- Energy only
- Availability obligation
- Reliability options
- Strategic reserve

FI: Strategic reserve
SE: Strategic reserve
I-SEM: Reliability option, centralised, market-wide
GB: Availability obligation, centralised, market-wide
DE: Strategic reserve
PL: Availability obligation, centralised, market-wide
BE: Reliability option, centralised, market-wide
FR: Availability obligation, decentralised, market-wide
CH: Strategic reserve
IT: Reliability option, centralised, market-wide

Source: AFRY, ACER.

5.2.1 Longlist of CRM design alternatives

The longlist comprises both existing implementations and conceptual designs, each described using the first-order building blocks introduced in Chapter 4.2.

Design alternative	Description[19]	Product obligation	Recover scheme
Targeted tender	**Fully centralised** procurement, **targeted** at new assets, with **fixed eligibility.**	Contracted providers have **no availability obligation**, and receive an annual payment, throughout the contract period. The units can freely operate in wholesale markets.	The **TSO** recovers costs through grid tariffs or via other means. Clawback mechanism ensures that potential windfall profits are shared between the provider and the TSO.
Strategic reserve 2.0	**Fully centralised** procurement, **targeted** at existing capacity with **fixed eligibility.**	Contracted providers, generation and/or DSR, are **ring-fenced** from the wholesale market, only being available for dispatch on the instruction of the TSO.	The **TSO** recovers costs through grid tariffs or via other means.
Targeted capacity payment	**Fully centralised** procurement, **targeted** at new or existing capacity, with **fixed eligibility.**	Contracted providers have **no availability obligation** and receive an annual payment. The units can freely operate in wholesale markets.	The **TSO** recovers costs through grid tariffs or via other means.
Market-wide capacity payment	**Fully centralised market-wide** procurement of existing capacity, with **fixed eligibility.**	Contracted providers have **no availability obligation**, and receive an annual payment. The units can freely operate in wholesale markets.	The **TSO** recovers costs through grid tariffs or via other means.
Centralised availability obligation	**Fully centralised market-wide** procurement of new or existing capacity, with **dynamic eligibility.**	Providers have an **availability obligation** and commit to making the awarded capacity available when called upon. The capacity can otherwise be operated freely in the market.	The **TSO** recovers costs through grid tariffs or via other means.
Decentralised availability obligation	**Fully decentralised market-wide** procurement of new or existing capacity, with **dynamic eligibility.**	Providers have an **availability obligation** and commit to making the awarded capacity available when called upon. The capacity can otherwise be operated freely in the market.	The **retailers and PIUs** pay for the availability of capacity to improve security of supply and to lower wholesale prices. Costs are recovered through the prices retailers charge end-users.
Centralised reliability option	**Fully centralised** procurement, **targeted** at new capacity with **dynamic eligibility.**	Providers have issued physically backed **energy reliability options**, rights (options) to buy electricity at a predetermined strike price, and must pay a 'difference' charge if the market price exceeds a predefined strike price.	The **TSO** recovers costs through grid tariffs or via other means. "Clawback" in form of the providers returning any positive difference between wholesale and strike price to the TSO, who is the buyer of the option.
Decentralised reliability option	**Fully decentralised market-wide** procurement of new or existing capacity, with **dynamic eligibility.**	Providers have issued physically backed **energy reliability options**, rights (options) to buy electricity at a predetermined strike price, and must pay a 'difference' charge if the market price exceeds a predefined strike price.	The **retailers and PIUs** pay for the option as an insurance against high wholesale prices, and the providers return any positive difference between wholesale and strike price. Remaining costs are recovered through the prices retailers charge end-users.

19. Outlining if the mechanism is market-wide or targeted, the eligibility, and how the volume is determined and procured.

5.2.2 Existing implementations in Europe

This chapter present insights into implementations across various countries, highlighting key lessons learned. While this is not an exhaustive overview of all implementations of the longlisted designs, it offers a curated selection of markets where valuable lessons can be drawn, particularly in relation to the assessment of second-order building blocks discussed in Chapter 7.8.

I-SEM, Ireland: Centralised reliability option

All interconnectors, dispatchable and non-dispatchable-but-controllable generator units are required to participate[20]. The reliability option holders are required to have physical capacity to back their contract. New and refurbished units have access to 10-year contracts, while existing capacity have access to annual contracts.

The maximum volume the participants can offer is limited by two factors. First, their net derated capacity, which adjusts their total capacity based on the reliability of their technology and size. Second, their firm offer requirement, which is a specific limit set for them. They must offer the lower of these two values.

If a participant wins capacity in the auction, their commitment is based on the derated capacity they were awarded. This means their obligation is tied to an adjusted availability level rather than their full installed capacity, reflecting how reliable their technology is expected to be.

They have difference payment obligation when the market reference price exceeds the strike price. The participants have to pay the positive differences between the imbalance price and the strike price for the portion of contracted capacity which has not been sold in the markets, regardless of whether they generate or not in the balancing market. They are therefore incentivised to run at times of scarcity and avoid incurring difference payments without any offsetting market revenue. This is creating a financial risk to contracted generators, when unsold generation is settled against the imbalance price.

In I-SEM, successful providers struggled to bring new capacity into operation within the four-year lead-time. This effectively resulted in a large withdrawal from capacity providers, which then needed to pay a termination fee, resulting in the CRM not being able to address the adequacy concerns.

20. Participation by generators below the de minimis threshold, variable units above the minimum threshold (10MW), units that have not come online and units that plan to close before the end of the capacity year is voluntary.

Belgium: Centralised reliability option[21]

The Belgium CRM is a market-wide CRM, open to all capacities that can contribute to resource adequacy, both existing and new capacity, storage and DSR – and for cross-border participation. Derating factors are calculated for each technology reflecting its reliability and its contribution to solve the security of supply concern. Capacity providers can therefore only get capacity contracts up to their derated capacity. The amount of capacity that can participate from neighbouring countries is calculated on a border-by-border basis. The strike price of the option is based on the SDAC.

The European energy crisis led to a massive shift in Belgium's energy policy. From being determined to phase out nuclear power, which to a large extent was the motivation for implementing a CRM, Belgium decided to extend the lifetime of its nuclear units. This massively reduced the need for the capacity already procured via the CRM.

Belgium has also seen a large share of the payments going to providers in neighbouring countries, as state aid rules require cross-border participation. There are several both positive and negative aspects of this:

- Derating factors are applied based on how much capacity is believed to be available when activation is needed. The Belgium TSO has also taken steps to ensure that the market algorithm, Euphemia, better reflects the CRM obligations.
- It may be politically challenging to implement a CRM that transfer money from the Belgian electricity consumers to electricity generators in other countries. On the other hand, from a cost perspective, if the required capacity was only procured in Belgium, the capacity payments would likely be significantly higher as foreign providers were successful in the procurement process.

Finland: Strategic reserve[22]

The Finnish strategic reserve is designed to ensure the security of electricity supply during peak demand periods in the winter months. This mechanism involves maintaining a reserve of electricity generation, DSR, and/or storage units outside the wholesale electricity market (i.e. ring-fenced).

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21. European Commission (2021), State aid SA.56848 (2020/N) – Belgium – Capacity mechanism, C(2021) 6518 final, 27 August 2021. Available at: ec.europa.eu; Elia (n.d.), Capacity Remuneration Mechanism, available at: elia.be
22. European Commission (2022), State aid SA.55604 (2020/N) – Finland – Strategic reserve, C(2022) 7399 final, 11 October 2022. Available at: https://competition-cases.ec.europa.eu/cases/SA.55604

The units need to be ready to respond within 12 hours from when they receive a dispatch order from the TSO and must be able to respond up to at least 200 hours, but are not open for cross-border participation as it is deemed "technically unfeasible". The strategic reserve is only to be used when all balancing reserves are likely to be exhausted. The imbalances in the market are at this point settled at minimum VoLL or at a higher value than the SIDC price limit.

The reserve operates by keeping certain electricity generation and storage units on standby, ready to supply electricity when needed. Additionally, DSR are prepared to reduce electricity consumption during critical times. These units do not participate in the regular electricity market, which helps to minimise any potential market distortions. The selection of units for the reserve is conducted through a transparent and competitive bidding process, ensuring that the most efficient and environmentally friendly alternatives are chosen.

Sweden: Strategic reserve[23]

Sweden is currently reviewing the future of its CRM[24]. The current mechanism is set to expire in March 2025, and consists of only one large oil-fired power plant.

In the late 2010s, the strategic reserve opened for DSR participation, which was expected to increase procurement in the short term and enhance demand flexibility in the long term[25]. In fact, the Swedish Government expected that 100% of the strategic reserve would be DSR by 2017/18[26]. The advantage of DSR is its quick activation, but the challenge lies in the industry's reluctance to commit in advance to longer shutdowns—especially when asked to do so years or months ahead. To attract DSR, procurement was moved closer to delivery and the DSR was allowed to forgo the capacity payments and rather be active in the spot market[27]. However, at the time it was concluded that this approach might be in conflict with Article 22(2) of the Electricity Regulation. As DSR was also unwilling/unable to committed for longer periods of time, DSR was excluded from the strategic reserve [28].

23. Svenska kraftnät (n.d.), Effektreserv, available at: svk.se
24. Svenska kraftnät (2023), A Future Capacity Mechanism to Ensure Resource Adequacy in the Electricity Market, Case No. Svk 2022/3774, 31 March 2023. Available at: svk.se
25. Regeringen (2010), Proposition 2009/10:113 – Effektreserven i framtiden, submitted 18 February 2010. Available at: riksdagen.se
26. Swedish Government (2010), Förordning (2010:2004) om effektreserv, issued 22 December 2010, repealed 1 July 2016. Available at: riksdagen.se
27. Holmberg, Pär & Tangerås, Thomas (2022), En teknikneutral elmarknad – med en effektiv elmarknadsdesign och nättariffstruktur, Institutet för Näringslivsforskning (IFN), 28 March 2022. Available at: https://www.ifn.se/media/tvfnip3s/holmbergtanger%C3%A5s220328.pdf
28. Svenska kraftnät (2023), A Future Capacity Mechanism to Ensure Resource Adequacy in the Electricity Market, Case No. Svk 2022/3774, 31 March 2023. Available at: svk.se

Poland: Centralised availability obligation[29]

The Polish CRM is a market-wide CRM, open to all capacities that can contribute to resource adequacy, both existing and new capacity, storage and DSR – and for cross-border participation. The capacity providers are obliged to deliver energy in the contracted period to ensure security of supply.

Poland has been facing some challenges with their CRM. In the initial years of implementation, capacity payments were predominantly awarded to coal-fired plants, rather than to gas-fired units as originally intended by the scheme's designers. Questions have also been raised regarding whether the volume of capacity procured is sufficient to meet identified system needs. Similar to the case in Belgium, a portion of the capacity payments is allocated to foreign capacity, which, as previously discussed, may be viewed negatively.

Great Britain: Centralised availability obligation

The GB was introduced a capacity mechanism in 2014 as part of the Electricity Market Reform (EMR) to ensure security of supply by providing predictable revenue streams for capacity providers. The mechanism operates through competitive auctions where participants bid for capacity agreements, committing to be available during system stress events. Successful bidders receive capacity payments in exchange for this availability, with penalties applied if they fail to deliver when required.

The mechanism is a market-wide, centralised capacity mechanism open to a broad range of technologies, including thermal generation, storage, DSR, and interconnectors. Auctions are typically held four years (T-4) and one year (T-1) ahead of the delivery period to secure long-term investments while allowing adjustments closer to real-time needs. The mechanism has been subject to ongoing reforms to improve cost efficiency and alignment with decarbonisation objectives, including changes to how carbon-intensive assets participate and the integration of low-carbon flexibility resources.

The GB availability obligation scheme attracted a large fleet of small diesel and gas engines and turbines, as units below 50MW would not require a longer and more complect permitting and connection process. This was unintended as the CRM aimed at promoting new CCGT plants. The CRM also excluded DSR, but after being challenged by market participants, DSR needed to be allowed to participate in the mechanism. This shows that a CRM inevitably creates winners and losers, and that it can be challenging to promote the "right" capacity.

29. European Commission (2018), State aid SA.46100 (2017/N) – Poland – Planned Polish capacity mechanism, C(2018) 601 final, 7 February 2018. Available at: https://ec.europa.eu/competition/state_aid/cases/272253/272253_1977790_162_2.pdf

France: Decentralised availability obligation

Suppliers have an obligation to ensure they have a certain volume of capacity certificates to cover for their consumers' demand during selected peak days. This happens via OTC trading with a central registry.

Capacity providers can trade based on certified availability and all technologies are eligible to participate. Capacity certification rules include specific rules for renewables to account for their intermittent generation profile. Contracted capacity participates as normal in the wholesale market.

New capacity is contracted by the TSO for a seven-year period under a CfD through a competitive tendering process. This capacity is in the next round offered by the TSO to the in the OTC market where suppliers procure their required volume.

The decentralised setup has been criticised for being too complex, while the overall CRM is considered to be too expensive. These issues may be linked, as it may be challenging in a fragmented market to spur the needed market liquidity and competition to move towards the "missing money" threshold – especially if the market is already dominated by a few large players. Also, a complex scheme may make it challenging for market participants to reduce peak demand and maximise available resources at times of system stress.

5.2.7 Conceptual designs

Not all longlisted designs have been implemented across Europe, the most relevant being the decentralised reliability option.

Decentralised reliability option (DRO)[30]

Unlike centralised CRMs, DRO operate on a decentralised basis. Retailers and large consumers are required to buy reliability options to meet their demand at critical times. Providers are committing their availability and receive an upfront payment (the price the buyer pays for the option) and forgo the revenue from price spikes. If the market price exceeds a predefined strike price, the capacity provider compensates the buyer for the difference.

The decentralised nature of the mechanism allows for market participants to themselves defined strike prices and other criteria for the option contract.

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30. AFRY Management Consulting (2015), Decentralised Reliability Options – Securing Energy Markets, Full Report v3.00, March 2015. Available at: https://afry.com/sites/default/files/2020-07/decentralisedreliabilityoptionsfullreport_v300.pdf; AFRY Management Consulting (2015), Decentralised Reliability Options – Securing Energy Markets, Summary Report v1.00, March 2015. Available at: https://afry.com/sites/default/files/2020-07/dro_mar2015_v100.pdf

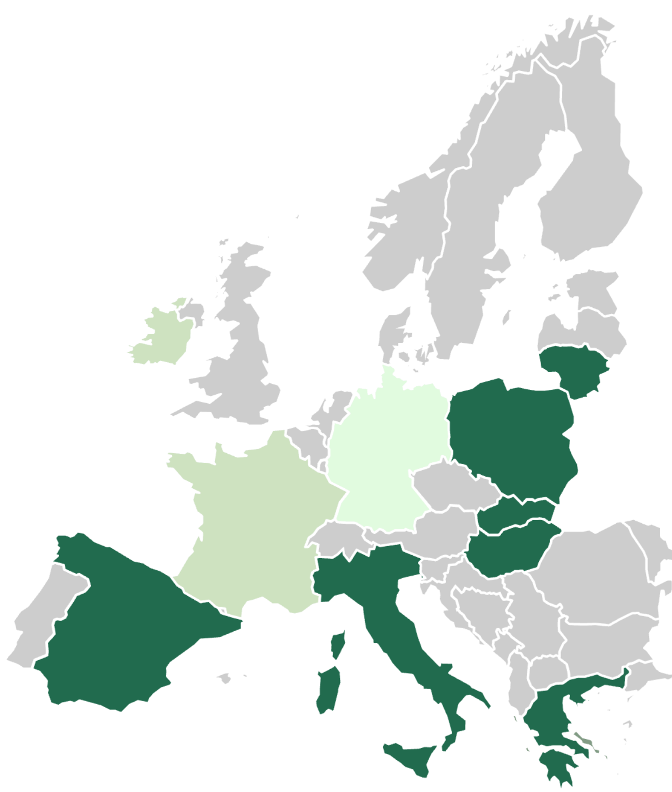
5.3 Non-fossil flexibility support schemes (NFFSS)

In addition to CRMs, several European countries have introduced other mechanisms aimed at increasing the flexibility of the power system, as shown in Exhibit 5.2. These schemes are primarily focused on enabling resources such as BESS, DSR, and other flexible capacity to better integrate renewable energy, improve grid reliability, and provide essential services like frequency regulation and peak load management.

It is important to note that these support schemes are *not* implemented under the new NFFSS regulation, as this regulation is still in the early stages and not yet in place across the EU, but they can provide potential examples of mechanisms that could be integrated under the NFFSS once it becomes operational.

Exhibit 5.2 – Different support schemes for flexible technologies are approved under the state aid regulation

The current support scheme typically supports DSR and BESS.



Thermals
DSR
BESS

LT: BESS
IR: DSR
PL: BESS
DE: Thermals, BESS
FR: DSR
SK: BESS
HU: BESS
IT: BESS
ES: BESS
GR: BESS

Source: AFRY, ACER.

5.3.1 Longlist of NFFSS design alternatives

The longlist of design alternatives includes mechanisms that resemble established capacity remuneration mechanisms (CRMs), existing support schemes approved under state aid regulations, and newly proposed concepts. While many of these may be considered conceptual in nature, this chapter does not provide further detail on the CRM-type designs beyond the summary provided in the accompanying table.

Each design is described using the first-order building blocks introduced in Chapter 4.2.

Design alternative	Description[31]	Product obligation	Recover scheme
Targeted flexibility tender	**Fully centralised** procurement, **targeted** at new assets, with **fixed eligibility.**	Contracted providers have **no availability obligation**, and receive an annual payment, throughout the contract period. The units can freely operate in wholesale markets.	The **TSO** recovers costs through grid tariffs or via other means. Clawback mechanism ensures that potential windfall profits are shared between the provider and the TSO.
Dispatchable flexible reserve	**Fully centralised** procurement, **targeted** at new assets, with **dynamic eligibility.**	Contracted providers are **ring-fenced** from the wholesale market, only being available for dispatch on the instruction of the TSO.	The **TSO** recovers costs through grid tariffs or via other means. Clawback mechanism ensures that potential windfall profits are shared between the provider and the TSO.
Centralised availability obligation – NFFSS	**Fully centralised** procurement, **targeted** at new capacity with **dynamic eligibility.**	Providers have an **availability obligation** and commit to making the awarded capacity available when called upon. The capacity can otherwise be operated freely in the market.	The **TSO** recovers costs through grid tariffs or via other means.
Centralised reliability option – NFFSS	**Fully centralised** procurement, **targeted** at new capacity with **dynamic eligibility.**	Providers have issued physically-backed **energy reliability options**, rights (options) to buy electricity at a predetermined strike price, and must pay a 'difference' charge if the market price exceeds a predefined strike price.	The **TSO** recovers costs through grid tariffs or via other means. "Clawback" in form of the providers returning any positive difference between wholesale and strike price to the TSO, who is the buyer of the option.
Decentralised reliability option – NFFSS	**Fully decentralised** procurement, **targeted** at new capacity with **dynamic eligibility.**	Providers have issued physically-backed **energy reliability options**, rights (options) to buy electricity at a predetermined strike price, and must pay a 'difference' charge if the market price exceeds a predefined strike price.	The **retailers and PIUs** pays for the option as an insurance against high wholesale prices, and the providers return any positive difference between wholesale and strike price. Remaining costs are recovered through the prices retailers charge end-users.
MACSE	**Fully centralised** procurement, **targeted** at new BESS, with **fixed eligibility.**	Providers have an **service-specific availability obligation** and commit to making the awarded capacity available to the TSO who offer it as time-shifting products to the market. The capacity can otherwise be operated freely in the market.	The **TSO** recovers costs through grid tariffs or via other means.
FRR availability obligation	**Fully centralised** procurement, **targeted** at new assets, with **fixed eligibility.**	Providers have an **availability obligation** and commit to making the awarded capacity available in the FRR EAM when called upon. The capacity can otherwise be operated freely in the market.	The **TSO** recovers costs through grid tariffs or via other means.

31. Outlining if the mechanism is market-wide or targeted, the eligibility, and how the volume is determined and procured.

5.3.2 Existing implementations in Europe – 'state aid'

A range of support mechanisms are implemented across various European countries. Most of these state aid-approved support schemes fall under the 'targeted flexibility tender' category, the simplest form of support scheme, in which flexible technologies receive subsidies without any direct obligations or commitments beyond their construction.

France: Demand response call for tender[32]

In addition to the CRM, the demand response call for tenders is designed to promote demand-side flexibility by incentivising electricity consumers to reduce consumption when needed. The scheme is open to consumption sites that can lower their electricity usage.

The tenders are structured into four categories based on the size of the consumption site and if the demand response is explicit or supply linked. Explicit demand response involves direct reductions in consumption when requested, whereas supply-linked demand response allows reductions to be integrated into broader electricity procurement strategies.

Ireland: DSO demand flexibility product procurement[33]

The mechanism is designed to enhance the flexibility of the electricity distribution network by promoting (primarily) DSR. It is part of a strategy that aims for 15-20% flexible system demand by 2025 and 20-30% by 2030.

The scheme seeks to procure up to 500 MW of flexibility products to manage congestion within the DSO grid. Participation is open to a range of technologies capable of delivering the required technical and operational performance. This includes solutions that reduce or shift demand to off-peak periods, as well as those that can inject power at or near their full contracted capacity for a minimum of four hours per day over most business days, typically for a duration of 3-6 months per year.

The procurement process follows a competitive assessment based on a 'most economically advantageous' approach. Key evaluation criteria include value for money, operability, deliverability, and the ability to support multi-market participation. By introducing this framework, the regulator aims to facilitate more efficient use of the electricity network, reduce the need for costly grid reinforcements, and support Ireland's broader decarbonisation goals.

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32. RTE (2024), Demand Response Call for Tenders, published 12 January 2024. Available at: rte-france.com
33. Commission for Regulation of Utilities (2024), DSO Demand Flexibility Product Procurement Decision Paper, CRU202469, published 12 July 2024. Available at: https://cruie-live-96ca64acab2247eca8a850a7e54b-5b34f62.divio-media.com/documents/CRU202469_DSO_Demand_Flexibility_Product_Procurement_Decision_Paper.pdf

Spain, Slovakia, Hungary: Investment support for BESS[34]

Several EU member states have implemented state aid schemes supporting BESS (and hydro pump storage where available) under the Temporary Crisis and Transition Framework for State Aid, which allows for targeted aid to address the energy crisis. These schemes generally focus on providing investment support for energy storage solutions to enhance grid stability and flexibility. While each scheme is tailored to the specific needs of the country, they share the common goal of supporting the integration of renewable energy sources, improving energy security, and enabling a more resilient energy infrastructure.

In Slovakia, the state aid scheme is designed to support the construction and operation of energy storage systems, primarily for renewable energy integration and grid balancing. Similarly, Hungary has introduced a state aid measure that focuses on promoting the deployment of energy storage solutions, with an emphasis on enhancing the capacity for peak load shaving and frequency regulation.

In Spain, the scheme follows a similar model, targeting the expansion of energy storage capacities to support grid flexibility and renewable energy integration. The Spanish scheme not only focuses on investment support for BESS but also incorporates mechanisms to ensure that these systems can participates in balancing services.

Germany: Investment support for gas power plant[35]

Similar to the schemes described above, Germany is planning to introduce a support for in total 12.5GW of new generation capacity (a mix of natural gas, hydrogen-ready and hydrogen-only power plants) as well as 500MW long-term energy storage under the new Power Plant Safety Act. The successful bidders must complete construction within 6 years and have no obligation to participate in any specific market (apart from the general REMIT requirements).

Primarily new, but also partly refurbished units, may participate. They are required to deliver 96 hours of continuous supply, and 2/3 are to be located in southern Germany. The latter is to be achieved by adding a component to the bid price to

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34. European Commission (2023), State aid SA.106554 (2023/N) – Slovakia – Investment support for electricity storage, C(2023) 7563 final, 3 November 2023. Available at: https://ec.europa.eu/competition/state_aid/cases1/202403/SA_106554_F0E8168D-0000-CF9B-989F-10E7ABBD77C3_80_1.pdf;
European Commission (2023), State aid SA.102428 (2022/N) – Hungary – Aid for energy storage facilities for the integration of weather-variable renewable energy sources, C(2023) 4257 final, 21 June 2023. Available at: https://ec.europa.eu/competition/state_aid/cases1/202330/SA_102428_F09B8D89-0100-C81D-9E22-4DB74E82A2DE_73_1.pdf;
European Commission (2023), State aid SA.103068 – Spain – Support for innovative electricity storage projects, C(2023) 4721 final, 7 July 2023. Available at: https://ec.europa.eu/competition/state_aid/cases1/202402/SA_103068_C06FED8C-0100-CB2A-A2A3-D0CD056F25DD_156_1.pdf
35. Bundesministerium für Wirtschaft und Klimaschutz (BMWK) (2024), Kraftwerkssicherheitsgesetz – Wasserstofffähige Gaskraftwerke, available at: bmwk.de

account for system cost savings. There are also some other technical requirements for the units, among them the possibility to deliver "grid-forming" – basically operate as a rotating mass to provide inertia.

The successful bidder will receive annual pay-outs over 15 years. The units will also be exposed to a clawback mechanism, where 70% of the income beyond a daily set trigger price. Using the concept of reliability options, there will also be a production-independent clawback to ensure availability when the system is under stress.

Italy: MACSE

MACSE is an electricity storage capacity procurement mechanism for new capacity. Successful providers are required to make the storage capacity, once built and operational, available to the TSO, which will offer the pooled storage capacity to third parties, in the form of standardised time-shifting products on a new centralised trading platform. The time-shifting products will give their buyers the possibility to use a virtual storage asset as if was theirs, to store and sell electricity at a later time when they wish to do so.

A single tender process will be organised at national level and at lower geographical level (i.e. bidding zone). This is done to ensure that Italy has sufficient storage capacity both on national level as well as in the bidding zones the reflect the regional resource situation.

Capacity providers enter into 15-year contracts with the TSO. These contracts offer a fixed annual premium, ensuring a stable revenue stream for the duration of the agreement. While the primary compensation is fixed, providers may have opportunities to earn additional revenue. For instance, they can participate in the balancing markets and retain a portion of the profits, potentially up to 20%.

5.3.4 Conceptual designs

The concepts outlined in this sub-chapter are designed to complement NFFSS design alternatives based on longlist of CRM designs.

FRR availability obligation

A potential type of flexibility support mechanism is to support technologies aimed at the balancing reserves. This approach may be implemented when a country identifies a structural need for additional balancing reserves but determines that the market alone is unable to deliver the required capacity. In such cases, a specific support mechanism can be introduced to incentivise the development of new flexible capacity, ensuring that sufficient balancing resources exists in the market to be able to maintain system stability.

Under this model, capacity providers would receive long-term contracts to develop and operate new flexible assets, such as BESS, DSR, or flexible generation. In return for this support, these assets would be required to participate in the balancing market, for example by being required to bid in the aFRR/mFRR CM or in the EAM. By supporting balancing capacity through long-term commitments, this mechanism provides investment certainty for developers while ensuring the power system has access to critical flexibility resources.

Dispatchable flexible reserves

The Dispatchable Flexible Reserve represents an alternative to the Strategic Reserve 2.0 design outlined in the CRM longlist but is implemented under the NFFSS regulation. As such, it is specifically targeted at new, non-fossil technologies and DSR, rather than extending the operation of existing capacity nearing phase-out. Dispatchable Flexible Reserves operate in a manner similar to strategic reserves by providing dedicated and restricted capacity, but with enhanced flexibility. The awarded capacity is excluded from competitive market participation and is activated exclusively during periods of critically high prices, preferably within the Single Intraday Coupling (SIDC), or alternatively within the Single Day-Ahead Coupling (SDAC). The solution does not require intervention by the TSO, as activation is triggered automatically by a predetermined market price threshold. Further detailed descriptions of this design can be found in the shortlist section (Chapter 6) of this report.


↑ Photos: Unsplash and Shutterstock

6. Shortlisting relevant design alternatives

This chapter marks a transition from a broad examination of potential capacity mechanism designs to a more focused analysis of the most promising alternatives for the Nordic market. Building on the comprehensive longlist presented previously, the design options are systematically narrowed to identify those most relevant for the region. The resulting shortlist forms the basis for the in-depth assessment and comparative analysis conducted in the subsequent chapters.

6.1 Summary

This selection includes the most promising market-wide and targeted designs, reflecting a comprehensive approach to addressing various challenges in the region. In shortlisting these designs, particular attention has been given to how the individual design could potentially be implemented in the Nordic market. The inclusion of both CRM and NFFSS alternatives ensures covering a broad spectrum of designs, providing insights into their effectiveness under different design objectives.

By incorporating both centralised and decentralised schemes, along with variants featuring fixed and dynamic eligibility criteria, the analysis captures a diverse set of potential design outcomes. This diversity supports a thorough evaluation of the approaches most suited to the region's specific needs. Moreover, evolved versions of established mechanisms, such as the strategic reserve and FRR CM, have been included to assess how these may be adapted to support an adequacy need. The resulting shortlist, presented in Exhibit 6.1, therefore offers a balanced view of innovative and refined solutions.

Exhibit 6.1 – Overview of shortlisted designs

MARKET-WIDE	CRM	Centralised availability obligation	Require capacity providers to commit to making their resources available when needed, with obligations set and enforced by a central authority, such as a TSO. All providers meeting the eligibility criteria receives capacity payments in exchange for providing system reliability.
		Centralised reliability option	Providers receive payments in exchange for committing to make their capacity available when needed, with obligations set and enforced by a central authority, such as a TSO. If market prices exceed a predefined strike price, the capacity provider must compensate the system operator for the difference, ensuring both availability and cost control. The strike price ensures that the provider is incentivised to offer its capacity when needed.
		Decentralised reliability option	Providers receive payments in exchange for committing to make their capacity available when needed, with obligations set and enforced by either retailors and PIUs. If market prices exceed a predefined strike price, the capacity provider must compensate the option holder for the difference, ensuring both availability and cost control. The strike price ensures that the provider is incentivised to offer its capacity when needed.
TARGETED	CRM	Strategic reserve 2.0	A modified version of the current strategic reserves in the Nordic market, which is centrally coordinated targeted at the extension of existing generation and to spur DSR. This includes CHPs who can switch from for example heat pumps or electric boilers to other fuels to produce heat. Awarded capacity is ring-fenced from the wholesale market, but ready to deliver when called upon by the TSO.
	NFFSS	Centralised availability obligation	Require capacity providers to commit to making their resources available when needed, with obligations set and enforced by a central authority, such as a TSO. The mechanisms is targeted towards new assets. Contracted providers receives capacity payments in exchange for providing system reliability.
		FRR availability obligation	Require capacity providers to commit to making their resources available in the FRR EAM when needed, with obligations set and enforced by a central authority, such as a TSO. This is similar to the existing FRR CM, however, assets are provided years in advance to allow for new-build and contract periods are longer. Providers must at minimum reach the FRR eligibility criteria.
		Dispatchable flexible reserve	Operate in a manner similar to strategic reserves by providing dedicated and restricted capacity, but with enhanced flexibility. The awarded capacity is excluded from competitive market participation and is activated exclusively during periods of critically high prices, preferably within SIDC, or alternatively within SDAC.

Source: AFRY.

6.2 Shortlisting of relevant mechanisms

This section refines the longlist of design alternatives presented in Chapter 5 into a focused shortlist. The shortlisting process is informed by the regulatory context, country-specific challenges and characteristics, as well as other key considerations outlined earlier in the report. Each design has been assessed at a high level to identify those options that best align with the region's strategic objectives and specific requirements. At the same time, the shortlist reflects a diverse set of pathways, ensuring a broad representation of potential approaches. The design alternatives presented in the following table will form the basis for the more detailed evaluation and comparison undertaken in the chapters that follow.

Design alternative	Reasoning	Shortlisted
CRM		
Targeted tender	Targeted, direct investment support for a specific technology, could effectively solve an identified need given perfect information. The mechanism would not allow for competition between technologies and not allow aggregators to provide their pooled capacity. It would also severely distort the market as the procured capacity could freely operate in the market, which is not aligned with the current Nordic energy-only market. This design is therefore not brought forward to the shortlist.	X
Strategic reserve 2.0	The general concept of a strategic reserve is well-known in the Nordic region and is a solution considered by some TSOs also for the future. However, this version of the strategic reserve is designed to address the limitations of traditional strategic reserve schemes, namely: - a lack of eligible MW for reservation - inflexibility due to long ramp-up times; and - complex TSO last resort dispatching rules. This could potentially be a cost-efficient solution to keep existing capacity and attract new sources of flexibility in the market.	✓
Targeted capacity payment	The mechanism is price-based, meaning that all eligible capacity providers receive a predetermined payment. Unlike auction-based mechanisms, which determine capacity prices through competitive bidding, this mechanism provides a fixed payment to all qualifying capacity resources. Since it is not a competitive procurement process, this is not in line with current EU law.	X
Market-wide capacity payment	The mechanism is price-based, meaning that all eligible capacity providers receive a predetermined payment. Unlike auction-based mechanisms, which determine capacity prices through competitive bidding, this mechanism provides a fixed payment to all qualifying capacity resources. Since the mechanism does not include a competitive procurement process, it is not in line with current EU law.	X
Centralised availability obligation	Relatively simple, market-oriented structure which seemingly can be easily adapted to the Nordic model. The design may also serve as a good benchmark for other designs.	✓
Decentralised availability obligation	Given that this design proved ineffective in the large French market, it is considered unlikely to be suitable for the smaller Nordic markets. Instead, the Decentralised Reliability Option is examined in order to ensure that at least one decentralised design is included in the shortlist.	X
Centralised reliability option	Well established, market-oriented structure. Centralised reliability options should lead to similar outcomes as an availability obligation; however, the option setup ensures revenues to the TSO which can use these revenues to lower grid fees.	✓
Decentralised reliability option	To include one decentralised design, the decentralised reliability option design is included. This is an innovative and un-tested design that allows each market participant to buy "insurance" (in the form of options) against high prices. The options should work as a price celling where each market participant can choose how high price peaks are tolerable, and at the same contributing to secure sufficient capacity for the system as a whole.	✓
NFFSS		
Targeted flexibility tender	Targeted, direct investment support for a new assets compliant with the NFFSS regulation, could help to promote certain types of technologies and solve identified needs. The mechanism would not allow for competition between technologies and not allow aggregators to provide their pooled capacity. It would also severely distort the market as the procured capacity could freely operate in the market, which is not aligned with the current Nordic energy-only market. This design is therefore not brought forward to the shortlist.	X

Centralised availability obligation – NFFSS	Relatively simple, market-oriented structure which seemingly can be easily adapted to the Nordic model. The design allows for targeting new assets, that are obliged to participate in the market, efficiently supporting system adequacy.	✓
Centralised reliability option – NFFSS	While considered effective as a market-wide scheme, but challenging to implement an option structure that entails only new, NFFSS compliant assets. An availability obligation structure is in this case considered more suitable.	**X**
Decentralised reliability option – NFFSS	While considered effective as a market-wide scheme, but challenging to implement an option structure that entails only new, NFFSS compliant assets – especially in a decentralised procurement structure due to the complexity. An availability obligation structure is in this case considered more suitable.	**X**
Dispatchable flexible reserve	The other NFFSS designs would be allowed to operate in wholesale markets, while the dispatchable flexible reserve would be ring-fenced from the market in a similar fashion as the strategic reserve 2.0 CRM. However, this design will aim at new, NFFSS compliant assets instead of keeping existing (potentially thermal) assets in the market. The scheme would be easy to implement and operate relative to other designs.	✓
FRR availability obligation	Changes in the electricity market may give rise to specific need for ancillary services. In such cases, a scheme aimed at a specific service may to a lesser extent distort the overall wholesale market, at least directly, than other mechanisms. The scheme would be easy to implement and operate relative to other designs, as it utilises existing markets.	✓
MACSE	MACSE is a relatively complex scheme aimed at BESS, in which market participants—typically generators of intermittent electricity—purchase time-shifting products in a newly established market operated by the TSO. While the scheme is likely to incentivise increased BESS participation, its complexity may limit broader applicability. Moreover, the scheme is not considered fit for purpose in the Nordic context, where flexibility is generally not a regular concern due to the significant share of hydropower in the system under normal conditions. Alternative mechanisms may achieve similar outcomes while enabling competition across different technologies. Consequently, MACSE and schemes with comparable structures are not deemed suitable for the Nordic region.	**X**

6.3 Deep dive into shortlisted solutions

This sub-chapter provide further insights into the CRMs and NFFSS shortlisted in the previous section. Using the building blocks established in Chapter 4.2. present a structured and comparative overview of each design. The content will serve as a basis for the assessment and recommendation in the final chapters of this report. It should also be noted that the overarching design concepts and building blocks are discussed in more detail in Chapter 4.

6.3.1 CRMs

Strategic reserve 2.0

A modified version of the current strategic reserves in the Nordic market, which is centrally coordinated targeted at the extension of existing generation and to spur DSR. This includes CHPs who can switch from for example heat pumps or electric boilers to other fuels to produce heat. Awarded capacity is ring-fenced from the wholesale market, but ready to deliver when called upon by the TSO.

As a last-resort instrument, activated only under extreme system stress and after all market-based solutions have been exhausted, it serves a broader system integrity function rather than addressing regular peak demand. Considering this, the recovery scheme should be non-targeted, where associated costs are best treated as a collective insurance premium and should be socialised across all network users.

Building block	Design choice	Description
Market-wide vs targeted	Targeted	Targeted capacity mechanisms focus on specific types of capacity or particular segments of the market. These mechanisms are designed to address specific needs or gaps in the electricity supply, such as incentivising the development of renewable energy sources or ensuring the availability of peaking power plants. By concentrating on particular resources, targeted mechanisms can provide tailored solutions to specific challenges within the electricity market.
Determining and securing volume	Fully centralised	In a fully centralised market, a central authority, such as the transmission system operator (TSO), is responsible for organising the procurement process. The central authority is contracting with providers to ensure system reliability.
Product obligation	Ring-fenced	Providers receive payment only for availability but must ensure firm availability with a high expectation of reliability throughout the contract period. Capacity is ring-fenced from the market and awaits dispatch instructions from the TSO. Units do not earn revenues from participating in the wholesale energy market, but activations are compensated by a cost-based payment. Activation happens in the **balancing market**, and if activated, balancing price is set to VoLL or the price cap in the intraday market, whichever is highest, in line with Article 22(2)(b) of the Electricity Regulation (EU 2019/943). Warming contract, to have the unit ready on short notice, is possible if required.
Eligibility & performance standards	Fixed eligibility	Fixed eligibility means that there are absolute minimum requirements that must be met to participate in the capacity mechanism. This is a known concept from for example the ancillary service markets where technical minimum standards must be met to participate. The criteria could also be set to aim the mechanism at for example only new, non-fossil assets in a given bidding zone or location.
Recovery scheme	TSO	Costs are socialised and borne by the TSO, who recovers them through regulated grid tariffs or via other means. The scheme should be non-targeted (kWh-based surcharge).

Centralised availability obligation – CRM

Centralised availability obligations require capacity providers to commit to making their resources available when needed, with obligations set and enforced by a central authority, such as a TSO. All providers meeting the eligibility criteria receives capacity payments in exchange for providing system reliability.

Market-wide CRMs should use targeted cost recovery because they address adequacy needs driven by peak demand. Charging those contributing most to peak load ensures fair cost allocation and strengthens price signals to reduce consumption and encourage flexibility.

Building block	Design choice	Description
Market-wide vs targeted	Market-wide	Market-wide capacity mechanisms are designed to ensure that all capacity required to maintain system reliability receives payment. This approach includes both existing and new capacity providers. It aims to provide a comprehensive solution to resource adequacy and to promote competition among a wide range of providers.
Determining and securing volume	Fully centralised	In a fully centralised market, a central authority, such as the transmission system operator (TSO), is responsible for organising the procurement process. The central authority is contracting with providers to ensure system reliability.
Product obligation	Availability obligation	Providers receive capacity payment solely for availability in the **SDAC**, with no additional compensation for activation, as they earn revenues from participating in the wholesale energy market. They are required to ensure the awarded capacity is available when called upon but are otherwise free to operate in the market.
Eligibility	Dynamic eligibility	Dynamic eligibility entails that the assets must meet a lower minimum requirement, but the quality of the service impacts the selection process (i.e. which providers are successful in the procurement process). The minimum requirement could for example be new, non-fossil assets. In the next stage, based on the needs assessment, one defines performance standards and associated derating factors.
Recovery scheme	TSO	Costs are initially borne by the TSO and subsequently recovered through regulated grid tariffs or alternative mechanisms. To ensure cost-reflectivity and support behavioural change, cost recovery is linked to peak consumption, by applying a kilowatt-based surcharge during predefined peak periods.

Centralised reliability option – CRM

In centralised reliability options, providers receive payments in exchange for committing to make their capacity available when needed, with obligations set and enforced by a central authority, such as a TSO. If market prices exceed a predefined strike price, the capacity provider must compensate the system operator for the difference, ensuring both availability and cost control. The strike price ensures that the provider is incentivised to offer its capacity when needed.

Building block	Design choice	Description
Market-wide vs targeted	Market-wide	Market-wide capacity mechanisms are designed to ensure that all capacity required to maintain system reliability receives payment. This approach includes both existing and new capacity providers. It aims to provide a comprehensive solution to resource adequacy and to promote competition among a wide range of providers.
Determining and securing volume	Fully centralised	In a fully centralised market, a central authority, such as the transmission system operator (TSO), is responsible for organising the procurement process. The central authority is contracting with providers to ensure system reliability.
Product obligation	Availability obligation	Providers receive capacity payment solely for availability in the **SDAC**, with no additional compensation for activation, as they earn revenues from participating in the wholesale energy market. They are required to ensure the awarded capacity is available when called upon but are otherwise free to operate in the market.
Eligibility	Dynamic eligibility	Dynamic eligibility entails that the assets must meet a lower minimum requirement, but the quality of the service impacts the selection process (i.e. which providers are successful in the procurement process). The minimum requirement could for example be new, non-fossil assets. In the next stage, based on the needs assessment, one defines performance standards and associated derating factors.
Recovery scheme	TSO	Costs are initially borne by the TSO and subsequently recovered through regulated grid tariffs or alternative mechanisms. To ensure cost-reflectivity and support behavioural change, cost recovery is linked to peak consumption, by applying a kilowatt-based surcharge during predefined peak periods.

Decentralised reliability option – CRM

In decentralised reliability options, providers receive payments in exchange for committing to make their capacity available when needed, with obligations set and enforced by either retailors and PIUs. If market prices exceed a predefined strike price, the capacity provider must compensate the option holder for the difference, ensuring both availability and cost control. The strike price ensures that the provider is incentivised to offer its capacity when needed.

Building block	Design choice	Description
Market-wide vs targeted	Market-wide	Market-wide capacity mechanisms are designed to ensure that all capacity required to maintain system reliability receives payment. This approach includes both existing and new capacity providers. It aims to provide a comprehensive solution to resource adequacy and to promote competition among a wide range of providers.
Determining and securing volume	Fully decentralised	Fully decentralised markets place the responsibility on individual market participants, such as retailers and generators or flexibility providers. These entities negotiate contracts directly based on their own assessments of future needs. Decentralised models offer greater flexibility, allowing participants to leverage their in-house knowledge, which can foster innovation and more tailored solutions. In a decentralised market, market participants are typically incentivised to secure volumes as they otherwise risk the exposure to price spike in the relevant market.
Product obligation	Energy reliability option	Providers receive payment for availability only, in form of issuing an option, and can offer the awarded capacity in the market. However, they must pay a 'difference' charge if the **SDAC** market price exceeds a predefined strike price.
Eligibility & performance standards	Dynamic eligibility	Dynamic eligibility entails that the assets must meet a lower minimum requirement, but the quality of the service impacts the selection process (i.e. which providers are successful in the procurement process). The minimum requirement could for example be new, non-fossil assets. In the next stage, based on the needs assessment, one defines performance standards and associated derating factors.
Recovery scheme	Retailers and PIUs	In a decentralised capacity mechanism, the responsibility of procurement and cost falls on the users of electricity. One could also require that the retailors charge a fixed fee to the end-user, similar to the Norwegian-Swedish electricity certificates system, to finance the capacity mechanism.

6.3.2 NFFSS

Centralised availability obligation – NFFSS

Centralised availability obligations, targeted towards non-fossil flexibility assets, require providers to commit to being available in the market when needed, with obligations set and enforced by a central authority, such as a TSO. These mechanisms target new investments, offering capacity payments in return for ensuring system reliability. Cost recovery should be targeted, as these schemes address adequacy risks driven by peak demand and limited flexibility, primarily caused by specific consumption patterns. Levies on peak consumption ensure that those contributing most to the need for capacity bear a fair share of the cost. This also strengthens price signals, encourages demand-side response, and promotes more efficient consumption, thereby reducing overall capacity needs.

Building block	Design choice	Description
Market-wide vs targeted	Targeted	Targeted mechanisms focus on specific types of capacity or particular segments of the market. These mechanisms are designed to address specific needs or gaps in the electricity supply, such as incentivising the development of renewable energy sources or ensuring the availability of peaking power plants. By concentrating on particular resources, targeted mechanisms can provide tailored solutions to specific challenges within the electricity market.
Determining and securing volume	Fully centralised	In a fully centralised market, a central authority, such as the transmission system operator (TSO), is responsible for organising the procurement process. The central authority is contracting with providers to ensure system reliability.
Product obligation	Availability obligation	Providers receive capacity payment solely for availability in the **SDAC**, with no additional compensation for activation, as they earn revenues from participating in the wholesale energy market. They are required to ensure the awarded capacity is available when called upon but are otherwise free to operate in the market.
Eligibility & performance standards	Dynamic eligibility	Dynamic eligibility entails that the assets must meet a lower minimum requirement, but the quality of the service impacts the selection process (i.e. which providers are successful in the procurement process). The minimum requirement could for example be new, non-fossil assets. In the next stage, based on the needs assessment, one defines performance standards and associated derating factors.
Recovery scheme	TSO	Costs are initially borne by the TSO and subsequently recovered through regulated grid tariffs or alternative mechanisms. To ensure cost-reflectivity and support behavioural change, cost recovery is linked to peak consumption, by applying a kilowatt-based surcharge during predefined peak periods.

Dispatchable flexible reserves

Dispatchable flexible reserve represents a new yet recognisable concept, functioning similarly to a strategic reserve by providing dedicated, restricted capacity, but with enhanced flexibility. Awarded capacity is restricted from competitively participating in the market and are instead activated exclusively during critically high-price periods within the Single Intraday Coupling (SIDC), the preferred variant, or alternatively within the Single Day-Ahead Coupling (SDAC), contingent upon acceptable merit order distortion levels – to be determined by decision makers. Delaying activation until closer to delivery through SIDC provides the market with opportunities to respond to price signals and resolve capacity issues independently, thereby minimising market distortion.

The mechanism is closely aligned with the NFFSS regulation, aiming to incentivise investment in new non-fossil flexible assets. Unlike traditional strategic reserves, often used to extend the life of ageing plants, dispatchable flexible reserves will typically involve higher per-MW costs due to the need for new or refurbished capacity. However, they offer greater flexibility in eligible technologies and are activated directly within market platforms, avoiding the need for complex TSO-led dispatch and enabling more dynamic multi-day and intraday system support.

Given its objective of addressing peak demand and flexibility gaps, cost recovery should also be targeted. Charging those whose consumption patterns drive these needs ensures fair allocation and reinforces market signals.

Building block	Design choice	Description
Market-wide vs targeted	Targeted	Targeted mechanisms focus on specific types of capacity or particular segments of the market. These mechanisms are designed to address specific needs or gaps in the electricity supply, such as incentivising the development of RES or ensuring the availability of peaking power plants. By concentrating on particular resources, targeted mechanisms can provide tailored solutions to specific challenges within the electricity market.
Determining and securing volume	Fully centralised	In a fully centralised market, a central authority, such as the transmission system operator (TSO), is responsible for organising the procurement process. The central authority is contracting with providers to ensure system reliability.
Product obligation	Ring-fenced (partly)	Providers receive payment only for availability but must ensure firm availability with a high expectation of reliability throughout the contract period. Capacity is ring-fenced from competitively participating in the market by having to offer the capacity in the **SIDC [2h] before gate closing time at a predetermined high price**. Alternatively, it can be within the SDAC or one of the following IDAs, contingent upon acceptable merit order distortion levels (to be determined by decision makers). Resources do not earn revenues when activated in the market, but activations are compensated by a cost-based payment.
Eligibility & performance standards	Dynamic eligibility	Dynamic eligibility entails that the assets must meet a lower minimum requirement, but the quality of the service impacts the selection process (i.e. which providers are successful in the procurement process). The minimum requirement could for example be new, non-fossil assets. In the next stage, based on the needs assessment, one defines performance standards and associated derating factors.
Recovery scheme	TSO	Costs are initially borne by the TSO and subsequently recovered through regulated grid tariffs or alternative mechanisms. To ensure cost-reflectivity and support behavioural change, cost recovery is linked to peak consumption, by applying a kilowatt-based surcharge during predefined peak periods. Any revenue generated from market activation at the designated strike price is used to offset the costs.

FRR availability obligation

FRR availability obligations require capacity providers to commit to making their resources available in the aFRR and mFRR EAM when needed, with obligations set and enforced by a central authority, such as a TSO.

In the aFRR and mFRR EAM and, capacity providers face cross-border competition and may be activated in coupled markets, provided that sufficient cross-zonal capacity is available. The Nordic aFRR and mFRR EAMs are expected to be integrated into the broader European market coupling initiatives, PICASSO and MARI respectively.

This mechanism resembles the existing FRR Capacity Mechanism (CM) but introduces three key differences. First, assets are secured several years in advance to enable the development of new-build projects. Second, contract durations are extended to provide the long-term revenue certainty needed for such investments. Third, the eligibility criteria—beyond those applied in the FRR CM—can be specifically tailored to target certain asset types, such as exclusively new, non-fossil assets, to ensure compliance with the regulatory requirements of the Non-Fossil Flexibility Support Scheme (NFFSS).

Under current balancing market regulations, the general rule is that contracts for balancing capacity must be concluded no more than one day in advance, and the contracting period must not exceed one day. Limited exemptions exist, allowing for lead-times of up to one month and contract durations of up to six months (as of 1 January 2026)[36]. However, the mechanism proposed here—featuring contracting lead-times of several years and contract durations of potentially up to 15 years—goes well beyond what is permitted under the current balancing market framework. As such, it cannot be implemented under the standard balancing market regulation and must instead be approved and implemented under a separate regulatory regime, such as the NFFSS, which is specifically designed to support long-term investment in non-fossil flexibility resources.

36. European Union (2019), Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity, Official Journal of the European Union, L 158, 14.6.2019, p. 54–124, Article 6(9). Available at: https://eur-lex.europa.eu/eli/reg/2019/943/oj

Building block	Design choice	Description
Market-wide vs targeted	Targeted	Targeted mechanisms focus on specific types of capacity or particular segments of the market. These mechanisms are designed to address specific needs or gaps in the electricity supply, such as incentivising the development of renewable energy sources or ensuring the availability of peaking power plants. By concentrating on particular resources, targeted mechanisms can provide tailored solutions to specific challenges within the electricity market.
Determining and securing volume	Fully centralised	In a fully centralised market, a central authority, such as the TSO, is responsible for organising the procurement process. The central authority is contracting with providers to ensure system reliability.
Product obligation	Service-specific availability obligation	Providers receive capacity payments solely for the obligation to make flexibility available by participating in the **aFRR/mFRR energy activation market (EAM)**. Awarded participants may generate further revenue through the participation in the FRR EAM markets if their bids are activated.
Eligibility & performance standards	Fixed eligibility	Fixed eligibility means that there are absolute minimum requirements that must be met to participate. This concept is well established in, for example, ancillary service markets, where technical minimum standards must be met as a condition for entry. The eligibility criteria can also be designed to target specific asset types, such as exclusively new, non-fossil assets, within a particular bidding zone or geographic location.
Recovery scheme	TSO	Costs are initially borne by the TSO and subsequently recovered through regulated grid tariffs or alternative mechanisms. To ensure cost-reflectivity and support behavioural change, cost recovery is linked to peak consumption, by applying a kilowatt-based surcharge during predefined peak periods.


↑ Photos: iStock

7. Assessment

This section evaluates the shortlisted capacity mechanism designs from multiple perspectives aligned with key design objectives, including cross-border participation and opportunities for Nordic harmonisation. The analysis begins with a discussion of the general opportunities and challenges associated with capacity mechanisms, followed by an exploration of market-wide versus targeted approaches—two overarching design principles that shape the choice of mechanism. The evaluation framework is then introduced, outlining the assessment criteria applied to each design. Subsequently, each shortlisted mechanism is analysed in detail, considering both its internal coherence and external implications. The final part of the section focuses on interoperability, the potential for cross-border participation, and second-order building blocks necessary for implementation. This approach aims to provide a comprehensive understanding of the key trade-offs involved in mechanism selection.

7.1 Summary

Opportunities: CRMs and NFFSS offer several benefits, including:

- Enhanced financial incentives to spur new investments
- Improved system security
- Potentially broader capacity mix, improving stability and opening for targeting technology-specific solutions based on need
- Allowing tailoring of solutions to address local needs

Challenges: However, despite these advantages, they also introduce several challenges:

- They can be expensive
- Risk of theory and practice mismatch
- Risk of market distortion in the form of:
  - Merit order distortion
  - Crowding out effect
- Risk of windfall profits
- Risk of perverse incentives

Main differences between market-wide and targeted mechanisms

Market-wide and targeted support schemes have different impacts on market dynamics. The choice between these two alternatives is one of the most critical initial decisions, as it influences the degree of market distortion and complexity, which in turn affects the risk of theory & practice mismatches.

Market-wide mechanisms remunerate all capacity providers, mitigating the crowding-out effect while compensating electricity generators for price distortions. While these mechanisms involve high-capacity payments, they are partly offset by lower and more stable consumer prices.

Targeted mechanisms, if not carefully designed (e.g., without restricting or ringfencing), can lead to significant crowding-out effects. Conversely, if ringfenced, they may contribute to merit order distortions. This trade-off is examined in detail in this chapter.

To better understand the risks associated with crowding-out effects, further analysis of investment behaviour and the determination of appropriate activation trigger prices is recommended. Mechanisms such as dispatchable flexible reserve should be designed based on insights from such studies.

Another key distinction between market-wide and targeted mechanisms is their complexity. Targeted mechanisms, while simpler, focus on direct financial support for specific capacity or flexibility gaps. In contrast, market-wide mechanisms involve higher financial stakes and are more susceptible to misalignment between theoretical design and market realities.

Assessment criteria

This chapter also evaluates the shortlisted designs against a set of predefined criteria (see Chapter 7.4). Exhibit 7.2 provides an overview of the key strengths and weaknesses of each design.

Interoperability, cross-border participation and Nordic harmonisation
In terms of interoperability, the assessment concludes that multiple market mechanisms can coexist, provided that their design minimises potential distortions. Implementing multiple market mechanisms simultaneously may even be beneficial to address distinct challenges.

Furthermore, the chapter examines cross-border participation, concluding that while this is generally beneficial, it introduces specific challenges that must be carefully addressed. For some targeted mechanisms, domestic security of supply might take priority, making cross-border participation less suitable in certain cases.

Several other aspects of harmonisation could also provide benefits to the Nordic region, including:

- Standardised needs assessments, improving coordination across markets.
- Common procurement platforms, facilitating efficiency and transparency.
- Harmonised regulatory frameworks, reducing market fragmentation.

The assessment highlights the advantages of harmonisation in these areas while acknowledging the complexities involved.

The final section of this chapter examines second-order design elements, drawing lessons from existing CRMs in Europe. Many European mechanisms have faced challenges due to suboptimal design choices at this level. Getting these elements right is crucial for ensuring a well-functioning mechanism. Key elements include:

- Contract duration and lead-times, ensuring investor confidence and operational feasibility.
- Short market time units, incentivising a diverse mix of flexibility resources.
- Balanced penalty structures for non-delivery, maintaining market discipline while avoiding excessive financial risk.

These insights provide a foundation for designing potential future CRM or NFFSS for the Nordic Region.

7.2 Opportunities and challenges

Capacity mechanisms and NFFSS, are designed to address the missing money problem, ensuring sufficient investment in generation and flexibility resources. However, these mechanisms come with inherent trade-offs. Decision-makers must carefully consider the synergies, risks, and unintended consequences of introducing additional market mechanisms on top of the existing energy-only market structure in the Nordic region.

- **Slippery slope effect:** Authorities may be tempted to expand the mechanism's use beyond its original intent and dispatch the providers more often, increasing market distortions.
- **Over procurement:** Difficulties in accurately predicting future capacity and flexibility needs may lead to over-procurement.
- **Windfall profits:** Revenue uncertainties can result in some participants earning significantly higher-than-expected returns, raising concerns over fairness and efficiency.
- **Risk of perverse incentives:** Market participants may engage in strategic behaviour to exploit the mechanism for financial gain, such as deliberately decommissioning assets to qualify for new investment support, rather than genuinely adding new capacity.

Conclusion

Capacity mechanisms and NFFSS can be useful tools for ensuring resource adequacy and system flexibility, but their implementation requires careful balancing of benefits and risks. Poorly designed mechanisms can lead to high costs, inefficiencies, and unintended market distortions that may undermine the effectiveness of the energy-only market.

Understanding these challenges is crucial, as misaligned policies risk creating a dependency on capacity payments, reducing market efficiency and leading to a negative spiral where competitive price signals weaken over time. Thoughtful design choices will be key to ensuring that these mechanisms complement, rather than compromise, the long-term sustainability of the electricity market.

7.3 Market-wide vs. targeted mechanisms

Before evaluating individual designs, this chapter examines the fundamental differences between market-wide and targeted mechanisms, as these categories represent two distinct approaches. The choice between these alternatives is one of the most critical initial decisions, as it significantly influences market dynamics, cost distribution, and system efficiency.

This chapter will compare market-wide and targeted mechanisms. The assessment focuses on opportunities and challenges where it differs between the two mechanisms.

7.3.1 Market-wide mechanisms

Market-wide mechanisms provide capacity payments to all eligible assets, including both existing generation and new investments, as long as they commit to delivering capacity within a specified timeframe (e.g., four years ahead). This broad participation enhances market liquidity but may also result in higher total payments and potential over-procurement.

Opportunities:

- **Avoids the crowding-out effect**, if implemented efficiently, since all capacity providers receive payments, reducing the risk of investment displacement.
- **Compensates for the price distortion** effect (lower prices) more evenly across the market, preventing disproportionate impacts on specific asset classes.
- **Ultimately leads to lower wholesale prices** for consumers, offsetting some of, or all, the costs associated with capacity payments.
- **Facilitates efficient dispatching and utilisation** of assets, as payments apply to all market participants, allowing for market-driven optimisation.

Challenges:

- **Expensive**: Since the entire market is remunerated, the capacity payments will be very high. In other words, high financial stakes are required that ultimately may burden consumers or taxpayers.
- **Theory & practice mismatch:** The complexity of market-wide capacity mechanisms, combined with the risk of suboptimal design choices, makes these schemes particularly vulnerable to failing in their intended purpose. In the worst case, they may be unable to secure any additional capacity at all.
- **Increases administrative and operational complexity** for all, as implementation requires extensive coordination and monitoring.
- **Derating factor:** Determining accurate capacity contributions (derating factors) is challenging, especially for hydropower, where seasonal variations significantly affect its role in system security. While this challenge exists for both market-wide and targeted mechanisms, it is far more pronounced in market-wide schemes. Since all existing capacity must be derated correctly, inaccuracies can significantly distort procurement outcomes, impacting both fairness and the total amount of capacity secured.

7.3.2 Targeted mechanisms

Targeted schemes, in contrast, restrict capacity payments to a specific subset of the market. This could be based on factors such as location, technology type, or the need for new investments. By limiting payments to only those resources deemed necessary, targeted mechanisms aim to reduce overall costs and better align with policy objectives, such as promoting non-fossil flexibility solutions.

While traditional CRMs can be classified as either market-wide or targeted, NFFSS mechanisms are inherently targeted due to their regulatory framework.

Opportunities:

- **Limited theory & practice mismatch:** A simpler and more pragmatic approach, reducing the risk of unintended outcomes due to market unpredictability.
- **Efficiency through selective payments:** Targeted mechanisms follow a more straightforward approach by directing payments only to the specific resources needed, rather than compensating all available capacity. This contrasts with market-wide mechanisms, where payments are distributed across all resources. By focusing only on selected capacity, targeted mechanisms can be more efficient and cost-effective, ensuring that payments go directly to securing the required assets.
- **Lower financial stakes:** Total payments are limited, as compensation is directed toward a specific subset of capacity rather than the entire market.
- **Enables precise targeting** of technologies or needs, fostering innovation and ensuring alignment with policy goals.

Challenges:

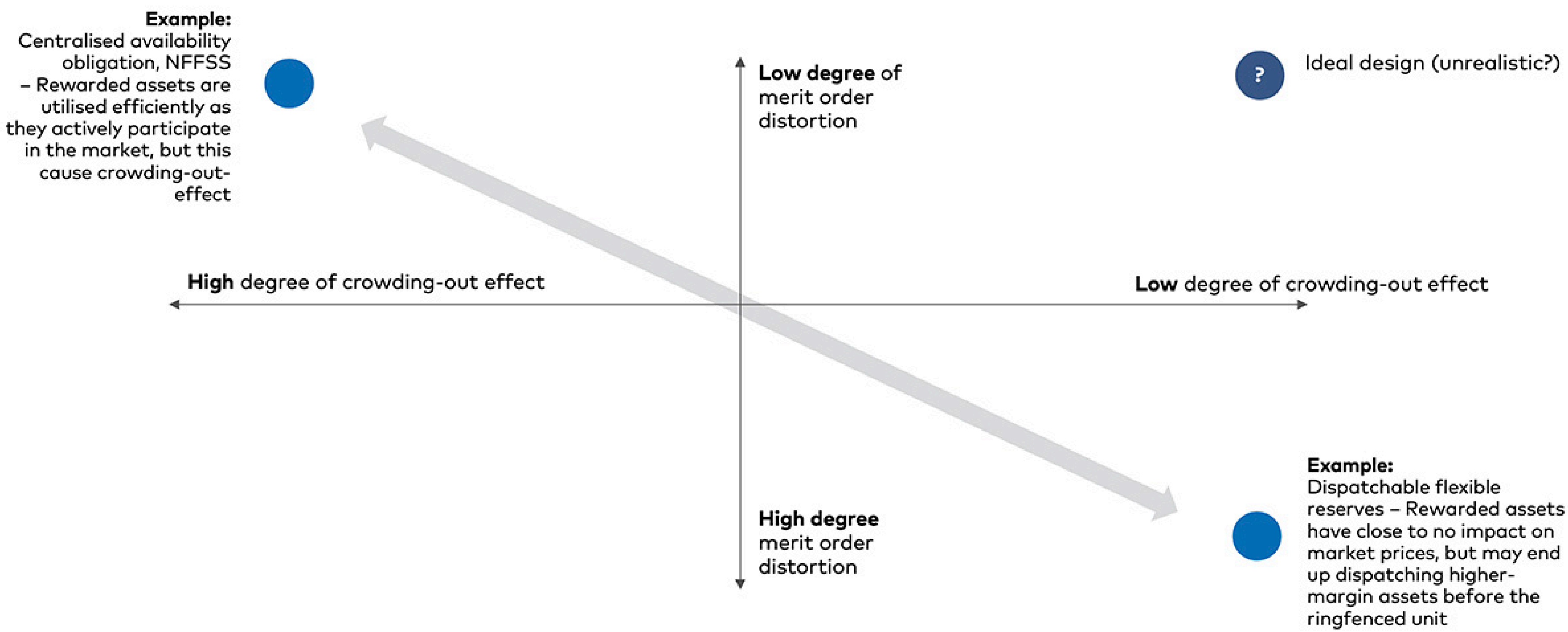
- **Market price distortion and crowding-out risks (if not ringfenced):** Assets that receive targeted capacity payments while simultaneously participating in regular market operations pose a significant risk of market price distortion and crowding out other resources. This can undermine market efficiency and, in the worst case, result in little to no additional capacity being secured. This is the primary challenge of targeted mechanisms, which is why CRMs are typically ringfenced when targeted, such as strategic reserves, ensuring they are only dispatched when other resources have been exhausted. However, most of the state aid-approved flexibility support schemes implemented in recent years have been targeted but not ringfenced. Their approval in the EU can largely be attributed to the timing, during the energy crisis, and the urgent need for additional flexibility in the countries where they were introduced.
- **Risk of low resource utilisation (if ringfenced or restricted)**: Ringfenced or restricted mechanisms ensure security of supply but risk paying for resources that are rarely or never used. Low utilisation of low margin resources can cause merit order distortion. This is raising concerns about cost-effectiveness and market efficiency. If allowed to operate based on marginal costs, they could reduce price spikes, although that is not their intended role. However, this would interfere with market signals that drive private investment in new capacity, causing crowing-out effect.
- **Slippery slope effect:** Policymakers may be tempted to change the rules and dispatch the reserve more often, causing more market distortion than initially intended.

- **Risk of perverse incentives**, where existing assets strategically decommission to qualify for capacity payments as new investments.

The primary trade-off in designing targeted mechanisms lies between the crowding-out effect and merit order distortion. Completely ringfencing an asset eliminates the crowding-out effect but risks dispatching higher-margin assets or resorting to costlier interventions, such as load curtailment, instead of utilising the ringfenced unit.

Designing a targeted mechanisms that simultaneously minimises market distortions and ensures efficient resource utilisation is inherently challenging, as these two objectives often conflict with each other. The following Exhibit 7.1 illustrates this trade-off.

Exhibit 7.1 – Trade-off between the crowding-out effect and merit order distortion



Source: AFRY.

The theoretical dilemma outlined above assumes perfect information and rational decision-making based on market fundamentals. However, this assumption is debatable. It is worth investigating to what extent investors base their decisions on the expectation that energy prices will reflect VoLL during scarcity periods.

There is significant uncertainty regarding how frequently, if ever, the market fails to reach equilibrium, resulting in scarcity events with prices at VoLL. Some investors may not even expect prices to reach the market's maximum price. For instance, SDAC currently caps prices at €4,000, a threshold not derived from VoLL but rather intended to mitigate buyers' financial exposure and bankruptcy risks. This cap is not guaranteed to remain unchanged and could be adjusted in either direction. By contrast, the intraday continuous market has a higher cap of €10,000, arguably allowing for pricing at VoLL in a Nordic context. However, reaching such extreme price levels raises the question of whether the resources offering flexibility at these prices are genuinely reflecting their costs or simply acting opportunistically.

Ultimately, preventing the activation of a ringfenced or restricted unit at a high but sub-maximal price, such as the SDAC cap of €4,000, does not necessarily cause a crowding-out effect. While it may limit the potential revenues of other flexible units bidding into the SIDC market at higher prices, the issue becomes one of fairness rather than market efficiency. This shifts the trade-off: activating a ringfenced or restricted unit at a price below VoLL does not crowd out other resources but instead prevents certain assets from capturing additional profits.

This remains speculative, and it is recommended that decision-makers conduct further analysis to understand investment behaviour better and determine appropriate activation trigger prices. The design of mechanisms such as dispatchable flexible reserve should reflect the insights gained from such studies.

7.4 Assessment criteria

As different market designs is explored in the following chapters, it is essential to establish a structured framework for evaluation. The assessment criteria outlined in this chapter provide a consistent basis for comparing and contrasting the proposed designs against the key objectives of an effective market structure. These criteria ensure that the chosen market design aligns with broader policy goals, supports the integration of non-fossil flexibility solutions, and maintains a well-functioning, efficient, and fair electricity market.

The assessment criteria are directly linked to the overarching design objectives and will be systematically applied to each of the shortlisted market designs. This structured approach ensures a transparent and balanced evaluation, highlighting the strengths and potential trade-offs of each alternative. A more comprehensive overview is provided in Annex A.

7.4.1 Overview of criteria

- **Low degree of distortion:** The solution should have a neutral or positive impact on existing business models and price signals, respecting past investments.
- **Market efficiency and inclusivity:** Ensures capacity is delivered at the lowest cost by fostering liquidity, innovation, and broad market participation.
- **Resource efficiency:** Maximises the utilisation of procured generation, storage, and DSR resources at both national and Nordic levels.
- **Effectiveness (in a Nordic context):** Ensures security of supply in a robust and reliable manner, independent of cost and complexity considerations.
- **Non-fossil:** Evaluates the extent to which the design promotes or prioritises non-fossil flexibility solutions.
- **Transparency:** Enhances market confidence by promoting clear decision-making, participation rules, and price formation mechanisms.
- **Investor confidence:** Provides sufficient incentives for investment while ensuring appropriate risk allocation for market participants.
- **Practical**
    - **Ease of implementation:** Considers technical, political, and regulatory complexity, as well as feasibility within a reasonable timeframe.
    - **Operational simplicity:** Assesses the ease of compliance, administration, and overall usability for both market participants and operators.

By systematically applying these assessment criteria to each shortlisted market design, an accurate and objective evaluation process is ensured. This approach enables a clear identification of trade-offs, synergies, and potential risks associated with different market structures. The evaluation framework provides a structured comparison, ensuring that each design is assessed in a transparent and comprehensive manner.

The upcoming chapters will evaluate each design against these criteria, ultimately guiding the selection of the most suitable approach to address varying adequacy needs. The assessment is structured into primary objectives, which represent the fundamental goals of the market design, and secondary objectives & design constraints, which encompass additional factors influencing feasibility, implementation, and operational effectiveness.

7.5 Assessment based on criteria

Each market mechanism presents trade-offs between different objectives. Centralised mechanisms (centralised availability obligation and centralised reliability option) offer liquidity and stability but can suppress price signals and require strong regulatory oversight. Decentralised reliability option allows more market-driven decisions but introduce transparency and coordination challenges. Strategic reserve 2.0 is highly targeted, minimising market distortions but restricting resource flexibility, while a dispatchable flexible reserve provides higher degree of flexibility but have higher degree of merit order distortion.

The chosen mechanism should ultimately strike a balance between the various criteria, ensuring market efficiency, optimal resource utilisation, and security of supply, while also promoting non-fossil resources and a fair distribution of costs and benefits.

Exhibit 7.2 provides a high-level overview of the strengths and weaknesses of different designs, supporting decision-making in achieving the optimal balance for the Nordic context while addressing country-specific needs.

Exhibit 7.2 – Assessment based on first order building blocks

The table give a high-level overview of the different strengths and weaknesses of different designs

			Low degree of distortion	Market efficiency and inclusivity	Resource efficiency	Effectiveness (in a Nordic context)	Non-fossil	Transparency	Investor confidence	Practical*
MARKET-WIDE	CRM	Centralised availability obligation	■■■□	■■□□	■■■□	■■□□	■■□□	■■■□	■■■□	■■□□
		Centralised reliability option	■■■□	■■□□	■■■□	■■□□	■■□□	■■■□	■■■□	■■□□
		Decentralised reliability option	■■■□	■■□□	■■■□	■□□□	■■□□	■□□□	■■□□	■□□□
TARGETED		Strategic reserve 2.0	■■■■	■■□□	■■■□	■■■■	■■□□	■■■□	■■■■	■■■■
	NFFSS	Centralised availability obligation	■□□□	■■■□	■■■□	■□□□	■■■■	■■■□	■■■□	■■□□
		FRR availability obligation	■■□□	■■■□	■■□□	■■■□	■■■■	■■■□	■■■□	■■■■
		Dispatchable flexible reserve	■■■□	■■■□	■■□□	■■■■	■■■■	■■■□	■■■■	■■■□

Source: AFRY.

* ease of implemententtion and operational simplicity

The following sub-section explains the rationale behind the scoring of different designs against the specified criteria in the table above.

7.5.1 Low degree of distortion

Market-wide CRMs exhibit a low degree of distortion, both in terms of crowding-out effects and merit order distortion, assuming they function as intended. However, this is seldom the case in practice, preventing them from achieving the highest possible score.

Strategic reserve 2.0 ranks highest in this category as it is entirely ringfenced and targets high-margin units, effectively limiting merit order distortion. Conversely, the targeted centralised availability obligation, i.e. NFFSS version, receives the lowest score due to its high level of market distortion by design, as it supports units that can operate freely in the wholesale market. This is a key reason why this mechanism is not recommended.

Dispatchable flexible reserve rank just below strategic reserve 2.0, as they permit dispatch not only as a last resort but also at a predefined high price. Furthermore, their restriction to new investments increases the risk of ringfencing low-margin units, which, in some cases, might otherwise have been dispatched in the market.

7.5.2 Market efficiency and inclusivity

Market-wide CRMs score relatively low in comparison to targeted mechanisms. While they enable broad participation, they may disproportionately favour incumbent players and established technologies. One notable challenge is defining the derating factor for hydropower with storage in hydro-dominant markets. Scarcity in these markets typically occurs during dry years, making it more of an energy issue than a capacity issue. This limitation is particularly pronounced in market-wide CRMs.

Additionally, these mechanisms have historically been sensitive to design failures, resulting in substantial costs due to the high-capacity payments embedded in the scheme.

In contrast, the NFFSS, being inherently targeted, mitigates these risks by compensating only for the required capacity or flexibility. Compared to strategic reserve 2.0, the NFFSS is specifically designed to incentivise new investments, thereby enhancing market liquidity and fostering innovation.

7.5.3 Resources efficiency

Market-wide CRMs generally promote efficient resource use, as they allow the awarded units to participate freely in the market. However, the FRR availability obligation risks ringfencing units that might otherwise be optimally deployed in other markets. Similarly, dispatchable flexible reserve carry a risk of underutilising flexible assets.

7.5.4 Effectiveness (in a Nordic context)

Strategic reserve 2.0 and dispatchable flexible reserve are considered the most effective mechanisms for ensuring security of supply in a robust and reliable manner. These mechanisms directly target resources capable of addressing the problem, and since they do not cause crowding-out effects, they contribute to securing supply provided they attract the right resources and are operated efficiently.

The FRR availability obligation also scores highly due to its targeted nature. However, it may displace other investments, reducing its overall effectiveness compared to a ringfenced alternative.

The NFFSS version of the centralised availability obligation, despite being a targeted mechanism, scores lower due to its crowding-out effects. By displacing other investments, it may fail to secure the intended capacity.

Market-wide CRMs generally score lower due to the mismatch between theoretical expectations and practical implementation, as discussed earlier in this chapter. The centralised reliability option is considered somewhat more efficient than the availability obligation due to its stronger financial incentives for delivery during scarcity periods. The decentralised reliability option is slightly less effective, as it is market-driven and more susceptible to under-procurement, whereas centralised CRMs tend to lean towards over-procurement.

7.5.5 Non-fossil

NFFSS mechanisms are explicitly designed to incentivise non-fossil resources, whereas CRMs do not inherently impose such restrictions. However, eligibility criteria can be used to encourage non-fossil participation within CRMs. Implementing this approach, however, can introduce new complexities, such as difficulties in attracting sufficient capacity, particularly in the case of strategic reserve 2.0.

7.5.6 Transparency

All mechanisms can be designed to ensure transparency. However, decentralised reliability option is generally considered less transparent due to their reliance on over-the-counter (OTC) trading and their inherent complexity.

7.5.7 Investor confidence

The centralised availability obligation provides predictability through centralised procurement, though it may favour established providers over new entrants.

The centralised reliability obligation offers stability but increases investors' risk exposure due to strike price uncertainty.

The decentralised reliability option presents higher counterparty risks, making it less attractive for investors.

strategic reserve 2.0 offers stability through fixed payments, with activations compensated by cost-based payments, yet they do not directly incentivise new investments.

The NFFSS version of the centralised availability obligation allows for fixed long-term contracts, which provide stability, but revenue estimation from market participation remains challenging.

Dispatchable flexible reserve also provides stability through fixed payments, with activations compensated through cost-based mechanisms.

Finally, the FRR availability obligation ensures stability through TSO-backed payments, with potential financial upside from market participation.

7.5.8 Practical (ease of implementation and operational simplicity)

Targeted mechanisms are generally easier to monitor and operate due to the limited number of assets involved. Strategic reserve 2.0 and the FRR availability obligation are particularly straightforward to implement, as they closely resemble existing mechanisms within the Nordic market.

By contrast, centralised CRMs are relatively complex, as they would introduce an entirely new framework into the Nordic system. These mechanisms require the definition of derating factors, a challenge that has proven difficult in other markets, and involve the operational complexity of monitoring all participating assets.

Decentralised reliability obligations are considered even less practical due to their innovative nature and the lack of practical implementation examples to draw from.

7.6 Interoperability

In some cases, implementing multiple market mechanisms simultaneously may be beneficial to address distinct challenges within the power market. While there are currently no indications that any Nordic market is pursuing such an approach, nor any formal recommendations to do so in the near future, it is important to explore the feasibility of such a setup. Ensuring that regulatory frameworks do not preclude future implementation can help preserve flexibility in policy design.

This chapter analyses the interoperability of different mechanisms, with a focus on CRMs and NFFSS. The key finding is that combining these mechanisms should not present fundamental obstacles, provided that implementation is carefully designed.

No regulatory blockers
Current EU regulations permit the simultaneous implementation of CRMs and NFFSS. Specifically:

- Paragraph 1, Article 19g of the Electricity Regulation states:
  "... Member States which apply a capacity mechanism shall consider making the necessary adaptations in the design of the capacity mechanisms to promote the participation of non-fossil flexibility such as demand-side response and energy storage, without prejudice to the possibility for those Member States to use the non-fossil flexibility support schemes referred to in this paragraph."
- Paragraph 2, Article 19g further clarifies that:
  "The possibility for Member States to apply non-fossil flexibility support measures pursuant to paragraph 1 of this Article shall not preclude Member States from addressing their indicative national objectives defined pursuant to Article 19f by other means."

The regulation allows for the parallel implementation of CRMs and NFFSS, provided that their design is adapted to ensure effective participation and avoid unintended consequences. The regulation does suggest that the CRM design (if already in place) could be adjusted to also include assets that could potentially be procured via a NFFSS, instead of having both.

Existing examples of multiple mechanisms in operation
Several markets have already implemented both flexibility support schemes and CRMs (Ireland, France, Italy), demonstrating that coexistence is feasible. This can be seen from the overview in Chapter 5, Exhibit 5.2.

Practical considerations and risks

From a technical and regulatory standpoint, there are no inherent barriers to operating CRMs and NFFSS in parallel. For instance, a market-wide CRM could be implemented to address adequacy concerns, while a targeted NFFSS could be introduced to incentivise specific types of flexibility.

However, challenges may arise in terms of market interactions and behavioural responses, including:

- **Potential for double payments:** Without clear design rules, assets could seek remuneration from both mechanisms, potentially leading to inefficiencies. Proper structuring and eligibility criteria can mitigate this risk.
- **Risk of over-procurement:** While different mechanisms may target distinct challenges, they may also address overlapping issues. For example, an NFFSS designed to incentivise flexible assets could inadvertently contribute to system adequacy, reducing the need for a CRM. If not carefully accounted for, this could lead to excessive capacity procurement and unnecessary costs.

Conclusion

The interoperability of multiple market mechanisms is feasible, provided that the design is carefully structured to avoid distortions. While regulatory frameworks allow for the coexistence of CRMs and NFFSS, successful implementation requires a clear strategy to prevent double payments, ensure cost efficiency, and manage interactions between mechanisms.

Future policy considerations should focus on dynamic market monitoring, ensuring that flexibility incentives remain aligned with overall adequacy goals without creating inefficiencies or unnecessary redundancies.

7.7 Nordic harmonisation

7.7.1 Cross-border participation

Both the regulation covering CRMs and NFFSS, as well as state aid rules, require the mechanisms to promote cross-border participation. CRM regulations impose stricter standards, while NFFSS guidelines may be perceived as less rigid. Cross-border participation can have big impact on the efficiency of the mechanisms and impact both the country implementing the mechanisms and its neighbouring countries. For the Nordic, this is particularly true, considering the close connected nature of the markets.

Rational for cross-border participation

The rationale behind these requirements is to prevent negative distortions in neighbouring markets and to improve global welfare. It is particularly true for market-wide mechanisms, as they are designed to compensate all generation and flexibility providers that commit to being available during periods of scarcity. Given the interconnected nature of the European electricity market through market coupling, assets in neighbouring markets inherently contribute to system adequacy whenever cross-border transmission capacity is available.

Unless interconnection constraints prevent power flows at the time of critical need, or if the neighbouring market is also facing stress conditions, external capacity will support the region security of supply. In cases where both markets are under strain, electricity should ideally flow to the market with the highest VoLL, though VoLL may not always accurately reflect the true willingness to pay. Alternatively, there may be no flow between markets, which some may perceive as the fairest solution in situations of widespread scarcity.

Considering this, the following outlines key risks of market distortions in neighbouring countries if cross-border participation is excluded, especially in market-wide mechanisms:

Market fragmentation and inefficient capacity allocation: By excluding foreign capacity providers, a CRM effectively limits competition to domestic participants, potentially leading to over-procurement and higher costs for consumers in the implementing country. Meanwhile, surplus capacity in neighbouring countries remains unaccounted for, despite being available to contribute to system adequacy. This fragmentation prevents optimal resource sharing across borders, reducing the overall efficiency of capacity allocation in the region.

Market distortion in the form of crowing-out effect: If a country implements a CRM without allowing foreign participation, domestic generators receive additional revenues, enabling them to bid lower in the wholesale market. This can suppress electricity prices, which in turn affects generators in neighbouring countries that do not benefit from the CRM. As a result, investors in those markets may face reduced profitability. This effect could ultimately lead to unintended consequences for both markets, where the effect of the CRM is reduced.

Misallocation of investments: Neighbouring markets that are interconnected but excluded from a CRM may experience distorted investment signals. If generators in the CRM country receive guaranteed capacity payments while those in neighbouring markets rely solely on market revenues, investors may be incentivised to prioritise capacity expansion in the CRM country rather than in locations where it could be more efficient from an energy-only perspective. This can lead to an unbalanced distribution of resources and underinvestment in flexible capacity where it is needed most.

Inefficient interconnector use and distorted trade flows: A market-wide CRM without cross-border participation may alter electricity trade patterns by making domestic capacity artificially competitive. Since the CRM country's generators receive additional payments, they can afford to offer lower prices in the wholesale markets, potentially crowing-out imports that would otherwise be cost-effective. This reduces the efficient use of interconnectors, leading to suboptimal cross-border electricity flows and increasing the risk of uneconomic exports or imports that do not reflect the true underlying cost of supply.

Spillover effects on security of supply in neighbouring countries: If a CRM over-procures capacity domestically while excluding foreign participation, it may inadvertently reduce the incentives for investment in neighbouring markets. This could result in reduced security of supply in those countries, making them more reliant on imports during stress events.

Challenges with cross-border participation

While cross-border participation within CRMs and NFFSS is ensuring efficient capacity allocation and minimising market distortions across countries, it introduces several practical and regulatory challenges. The nature and severity of these challenges can vary depending on whether the mechanism is market-wide or targeted.

Incomplete mitigation: Cross-border participation does not fully mitigate the negative externalities of capacity markets on neighbouring consumers, generators, and interconnectors.

Unfair welfare distribution: The distribution of welfare may be perceived as unfair to consumers in the implementing market, as they indirectly remunerate capacity abroad. In Belgium, 47% of capacity awarded contracts during last auction in 2024 were located outside of Belgium, meaning Belgian consumers are remunerating Dutch and German generators.

Domestic security of supply: Depending on the availability of interconnectors during periods of scarcity, cross-border participation may undermine the primary objective of ensuring domestic security of supply. Even if foreign assets are technically available, the ability to deliver their capacity depends on the availability of transmission capacity during a scarcity event.

Political risk: In the long run, there is a political risk that there might be less available cross-zonal interconnection than today.

Regulatory compliance: Monitoring and enforcing commitments from foreign capacity providers can be challenging, as these assets operate under a different regulatory authority. Mechanisms must be established to verify that foreign capacity is:

- Available when needed.
- Not simultaneously committed to another mechanism in its home market.
- Delivering its promised contribution during system stress events.

Risk of unequal treatment: Market-wide CRMs typically set uniform remuneration levels for all participating assets. However, foreign capacity may face different cost structures, such as different regulatory charges or support mechanisms in their home market. If these differences are not accounted for, the CRM could unintentionally favour either domestic or foreign capacity, distorting investment signals.

Complexity of capacity contribution calculation: Market-wide CRMs require robust methodologies to determine the contribution of foreign capacity to system adequacy. This involves modelling probabilistic availability, considering potential scarcity events in both markets, and assessing how cross-border flows behave under stress conditions. Failure to account for these factors correctly could lead to over- or under-procurement of capacity.

Risk of reduced effectiveness of targeted schemes: Targeted mechanisms are often implemented to correct specific domestic missing money problem. Allowing foreign capacity participation could weaken the intended impact. For instance, if a targeted mechanism is aimed at addressing local flexibility shortfalls, but a significant portion of the contracted capacity comes from foreign sources, the scheme may fail to deliver the intended reliability benefits.

7.7.2 Harmonised needs assessment

Today, each Nordic country conducts its own capacity adequacy assessment and flexibility needs assessment, using different methodologies, assumptions, and risk tolerances to determine how much capacity is required to ensure security of supply. When integrating cross-border participation in capacity mechanisms or NFFSS, these differences can create several challenges:

Inconsistent definitions of adequacy: Some markets assess adequacy based on loss of load expectation (LoLE), while others may use expected energy not served (EENS) or different reliability criteria. This variation can lead to misalignment in how much capacity is deemed necessary and which resources qualify for support.

Diverging risk assumptions: Capacity adequacy assessments often rely on assumptions about peak demand, weather conditions, interconnector availability, and generator outages. If a foreign capacity provider is assessed under a less conservative methodology than the importing country's mechanism, it might not be as reliable as expected during stress periods.

Timing of needs assessments: Different markets conduct their assessments at different intervals, meaning that a generator might be deemed essential in its home market at the same time it is contracted as foreign capacity elsewhere. This could lead to conflicts in capacity obligations if scarcity events occur simultaneously.

Impact on cross-border contracting: If countries do not recognise each other's methodologies, there may be reluctance to rely on foreign capacity, reducing the effectiveness of cross-border participation and potentially leading to over-procurement in some markets.

To mitigate these challenges, greater harmonisation of capacity adequacy methodologies and flexibility needs assessment across Nordic markets is needed, ensuring that cross-border contributions are assessed consistently and can be relied upon when needed.

7.7.3 Harmonised rules

One of the key challenges in integrating mechanisms across European electricity markets is the variation in national rules and regulatory frameworks. Differences in eligibility criteria, payment structures, capacity obligations, and penalty mechanisms can create barriers to effective cross-border participation and lead to inefficiencies in capacity procurement.

A harmonised approach to CRM or NFFSS rules across the Nordic region could improve efficiency, security of supply, and investment certainty by addressing the following challenges:

Inconsistent eligibility criteria: Some countries impose stricter requirements on which assets can participate in capacity mechanisms or NFFSS, such as excluding certain technologies or setting specific environmental performance standards. This can limit cross-border participation if foreign assets do not meet the same criteria as domestic ones.

Conflicting capacity obligations: Market participants may face different commitment periods, testing requirements, and performance expectations across jurisdictions. A capacity provider operating in multiple markets may struggle to comply with overlapping or conflicting obligations.

Misaligned procurement and payment structures: Differences in auction design, clearing prices, and contract durations can distort investment signals. For example, a generator might be incentivised to participate in a CRM with higher payments, rather than in the market where its capacity is most needed.

Disparities in penalty and enforcement mechanisms: Some markets impose strict penalties for non-delivery of capacity, while others have more lenient enforcement mechanisms. This could lead to unequal risk allocation, where foreign providers may be subject to weaker penalties than domestic participants.

Uniform trigger price: For strategic reserve 2.0 or dispatchable flexible reserve, distortions occur when trigger prices vary between countries. Using maximum prices in existing markets, which are consistent across all EU markets due to market coupling, eliminates this issue. Alternatively, if the VoLL or other rules determine the trigger price, establishing a common VoLL or trigger price can mitigate distortions.

7.7.4 Harmonised procurement platform

Harmonising the procurement of capacity and/or flexibility across the Nordic countries can help mitigate some of the challenges related to cross-border participation. Although the different markets seek to procure different products, it should be feasible to design a common platform. A harmonised approach offers several advantages:

Cost sharing: Enables the sharing of costs associated with implementing and operating the mechanisms, leading to greater economic efficiency.

Sharing of resources: When scarcity events are unlikely to occur simultaneously across different markets, a single capacity or flexibility provider can ensure security of supply in multiple connected markets. This reduces costs by decreasing the number of required providers within the region and utilising a broader range of plants. Consequently, cost for end consumers decline as markets share the costs for the same volumes.

Streamlined: Ensuring similar functions across the Nordic region reduces administrative and operational burden, both for operators and market participants operating in multiple markets.

Example to illustrate the feasibility of a harmonised solution

A common Nordic mechanism is feasible. Drawing inspiration from the SDAC platform, the Nordic market can be divided into zones, each managed by a centralised single buyer from each country. Zones with verified needs for additional capacity or flexibility would specify their demand quantities, creating a comprehensive demand map across Nordic price zones. In zones where no additional capacity is needed, demand would be set to zero. For example, Norway could opt out of purchasing reserves while still participating in the market and supporting the mechanism. This approach is equitable, allowing Norwegian assets to participate, ensuring increased competition and efficient allocation of resources.

Similar to SDAC, a central entity, such as the Nordic TSOs, would forecast available cross-zonal capacity between zones over the entire contract period (e.g., 15 years).

This forecast would establish ‘efficiency factors’ or ‘locational derating factors’, indicating how much MW capacity an asset in one zone can provide to another zone during scarcity events.

For example, an asset in Zone A may supply capacity to Zone B but be derated by X% to reflect its ability to provide electricity cross-border during a scarcity in Zone B. This locational derating factor could work in combination with efficiency factors such as:

- Technology-specific derating factor: Assessing the asset's reliability during scarcity events.
- Ramping speed: The capability to quickly adjust output levels (seconds, minutes or hours).
- Operational limits: Maximum continuous operation time and required resting time.

To ensure the system's reliability, national regulators should commit to maintaining the physical cross-zonal capacity capabilities. This commitment guarantees that capacity providers can fulfil their obligations during scarcity events, preventing undermining the results of the mechanism.

7.8 Second order building blocks

Second-order building blocks apply to all designs, and their decisions are not dependent on which shortlisted design is ultimately chosen. As a result, these decisions can be made separately and typically at a later stage, once the overall direction has been clarified. However, this does not diminish their importance. As outlined in this paper, many existing CRMs in Europe have encountered challenges due to suboptimal design choices at this level. The following sections outline key considerations for each of the five second order building blocks.

7.8.1 Contract type and duration

Generally, longer contracts are positive for investors who typically seek stability and predictability, particularly if the construction of new assets are envisioned. However, as the identified adequacy concerns might not materialise, long contracts lead to a higher risk of over-procurement. Conversely, shorter contracts can be more adaptable to changing market conditions, reducing the risk of over-commitment. Shorter contract will typically also attract “low hanging fruits” like DSR, BESS, lifetime extensions, and refurbishments. However, it is likely to fail in attracting new-build assets with higher initial investment costs.

Furthermore, long-term contracts can potentially distort market signals by locking in certain capacities, thereby affecting the flexibility of the market to adapt to new technologies or changing demand patterns.

It is possible to accommodating different types of capacity providers through varied contract durations. This can help to ensure a balanced mix of resources, enhancing overall system reliability and resilience. It may also lower the risk of both over- and under-procurement as the amount of resources secured via short contracts can be adjusted to reflect changing market conditions. This gives a higher degree of freedom for the TSO.

A shaped contract can allow assets to seasonally shut down, thereby lowering direct procurement costs. This approach is particularly relevant for large thermal units, which can benefit from reduced costs during periods of low need. With shaped contracts, it is also possible to allow the unit to operate freely in the market in periods where the TSO deems the need to be low. This would increase the resource efficiency but also lead to higher market distortion – especially if the unit is competitive in the wholesale market.

Lessons learned

Attracting new investments vs. retaining existing capacity: In the UK's CRM, new generation projects could secure contracts up to 15 years, whereas existing plants were limited to one-year contracts. This disparity led to challenges in balancing the encouragement of new investments with the retention of existing capacity[37]. 1-year contracts predominantly attracted existing fossil-based resources (small-scale diesel/gas engines), as the short commitment period did not incentivise new large-scale generation investments.

Technology lock-in: Some European countries have implemented CRMs to ensure sufficient levels of flexible and dispatchable capacity. However, these markets have predominantly allocated payments to thermal technologies like gas, coal, and nuclear plants, with gas-fired assets accounting for about half of the capacity payments. This allocation may not align with long-term decarbonisation goals.

7.8.2 Duration of need and market time unit (MTU)

The duration of need is becoming an increasingly critical challenge with the growing reliance on variable RES, leading to periods of dunkelflaute. To address this, the design of support mechanisms must be adapted accordingly. While eligibility criteria should consider the duration of need, overly strict requirements could limit competition and risk failing to deliver an effective solution.

37. Newbery, D. (2020). Capacity Remuneration Mechanisms: Comments on Experience and Implementation Challenges. Cambridge: Energy Policy Research Group, University of Cambridge. Available at: https://www.jbs.cam.ac.uk/wp-content/uploads/2024/02/eprg-D.-Newbery_Comment_24Mar2020.pdf

To enhance market efficiency and inclusivity, the mechanism should accommodate a diverse range of market participants by segmenting the duration of need into smaller MTUs during procurement. This approach would not only foster competition but also support welfare distribution, as a wider variety of assets could generate revenues by providing services.

Lowering entry barriers, such as reducing MW thresholds or MTU sizes, has proven effective in several markets, including day-ahead, intraday, and mFRR markets. There is reason to believe that similar adjustments would enhance competition in capacity and flexibility mechanisms and as well, and this aligns with ACER's report on barriers to demand response and other distributed sources from 2023[38].

Furthermore, new system technologies, such as the automatic activation of units directly from the TSO's control centre, enable greater reliance on a fleet of smaller assets to ensure security of supply. This fleet can be procured directly by the TSO or offered as a service by aggregators, further increasing flexibility and resilience in the system.

7.8.3 Procurement mechanism

Auctions trading platforms facilitate transparency, where price discovery is public, and all bids are treated equally given pre-defined criteria (i.e. high visibility to the procurement process, results, needs, commitments, etc.). A pay-as-clear auction provides additional profits for cost-efficient solutions, potentially making their participation more attractive than in a tender. However, launching a new auction platform is time consuming and potentially costly and is therefore less attractive if procurements are rarely taking place and overall procured volume low.

Tenders are easier to launch relative to an auction platform, but selection of successful bidders is more complex, and the bid selection process may be considered less transparent than an auction. Tenders is preferable when there are few potential suppliers and other criteria than price are crucial.

Lessons learned

Complexity in decentralised approaches: France's decentralised capacity market, which relied on over-the-counter trading, resulted in complex transactions, reducing transparency and liquidity.

38. ACER (2023) 'Demand response and other distributed energy resources: what barriers are holding them back? 2023 Market Monitoring Report. Available at: https://www.acer.europa.eu/sites/default/files/documents/Publications/ACER_MMR_2023_Barriers_to_demand_response.pdf

7.8.4 Lead-time and frequency

When designing capacity and flexibility mechanisms, policymakers must align procurement timelines with the lead-times of different technologies. A short lead-time in effect disqualifies new build generation and attracts "low hanging fruits" like DSR and BESS.

Key considerations include:

- **Early procurement**: To ensure long-lead-time technologies, providers must receive commitments well in advance to secure investment and timely deployment.
- **Short-term flexibility**: Fast-responding resources like DSR and BESS, as well as extending lifetime of existing assets, can quickly be procured to manage near-term adequacy risks.
- **Regulatory streamlining**: Before the procurement process, permitting and grid connection processes must be streamlined to avoid delays and secure project delivery.
- **Diversified support structures**: Policymakers should consider using differentiated contract structures tailored to the lead-times of the different technologies that can solve the adequacy need.

Another aspect is that frequent (annual) procurements will attract more providers as projects can be re-submitted in later auctions. It also allows for flexibility with regards to new needs assessments and allows for learning from the previous rounds for all stakeholders.

Lessons learned

Insufficient lead-time for new-build: In I-SEM, most of the new-build capacity awarded contracts in 2017 withdrew as they did not manage to bring new capacity into operations within the four-year long lead-time between contract award and delivery. This led to delayed capacity and resulting in contract terminations and penalties, illustrating the importance of realistic lead-times for new investments.

Balancing short and long-term: A critical lesson from GB is the strategic importance of determining how much capacity to procure well in advance (T-4 auctions, for delivery four years ahead) versus closer to the actual delivery year (T-1 auctions). In GB's first capacity auction, a significant shortfall emerged due to over-reliance on the T-4 auction. This occurred because some contracted new-build projects failed to materialise within the four-year lead-time, resulting in a notable gap in available capacity. Although this shortfall was later mitigated by allowing interconnectors into subsequent auctions, it underscores the inherent tension in procurement timing: earlier auctions provide the necessary lead-time to attract a broader range of investment, while later auctions offer greater precision in determining actual system needs but significantly limit the choice of technologies that can feasibly be deployed within a short timeframe.[39]

7.8.5 Nature of penalty

Penalties play a critical role in ensuring that providers deliver services in accordance with their commitments and that consumers receive the quality and reliability for which they have paid.

Providers who operate a diverse portfolio of assets may financially benefit from non-delivery during periods of system stress, as increased market prices can offset penalties through enhanced revenues from their remaining operational assets. It is therefore worth considering whether administered penalties should vary depending on specific provider characteristics, such as portfolio composition.

However, policymakers must carefully balance penalty levels, as excessively high penalties could deter providers from participating in procurement processes. Reduced participation can ultimately lead to higher overall system costs, whereas more moderate penalties may encourage greater participation and thus more competitive procurement outcomes.

Lessons learned

Effectiveness of penalty structures: An important lesson from GB's CRM is the critical role of penalty design in ensuring contracted capacity delivery. During the early GB auctions, modest penalties allowed providers, such as a large-scale CCGT project contracted at a relatively low clearing price, to relinquish their contracts without substantial financial repercussions. This created significant gaps in procured capacity, highlighting the necessity for penalties sufficiently stringent to deter non-delivery, yet balanced enough to avoid discouraging participation altogether.

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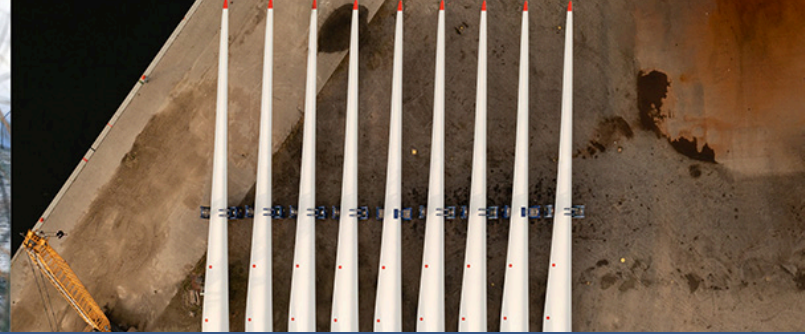
39. Newbery, D. (2020). *Capacity Remuneration Mechanisms: Comments on Experience and Implementation Challenges.* Cambridge: Energy Policy Research Group, University of Cambridge. Available at: https://www.jbs.cam.ac.uk/wp-content/uploads/2024/02/eprg-D.-Newbery_Comment_24Mar2020.pdf



↑ Photos: iStock

8. Recommendations

This chapter bring together key insights from the assessment and put them into the Nordic context. It provides recommendations for specific capacity market mechanisms based on the drivers which could cause scarcity events. The chapter further examines cross-border participation, with a particular focus on the proposed mechanisms, and discusses additional harmonisation initiatives alongside second-order building blocks.

8.1 Summary

This section provides strategic recommendations for addressing potential adequacy and flexibility challenges within the Nordic markets. It emphasises that selecting appropriate mechanisms, whether market-wide or targeted, should depend on thorough assessments of system requirements and political objectives, which fall outside the scope of this particular study. Therefore, the recommendations may be considered as a toolkit for use in a variety of scenarios, ranging from likely occurrences to less frequent, combined risk events.

The recommendations assume that common isolated events, such as 'dunkelflaute' (extended periods of low renewable electricity generation), cold winters, dry years, and supply outages, are in general adequately addressed through existing market mechanisms, thus requiring no additional interventions. These assumptions are intended to illustrate likely outcomes; however, no detailed forecasting analysis has been conducted within the scope of this report.

However, if the risk of several events happening at the same time is deemed too high, it may necessitate additional, targeted mechanisms. Generally, dispatchable flexible reserve is recommended as the most suitable design to efficiently provide the required flexibility while causing minimal market distortion. In extreme and infrequent scenarios, such as a combination of dunkelflaute, cold winters, and significant supply or interconnection outages, the recommended approach is the implementation of 'strategic reserve 2.0'.

For cross-border participation, the report concludes that dispatchable flexible reserve could beneficially incorporate cross-border cooperation when multiple countries implement similar mechanisms, provided transmission constraints are carefully considered and accounted for using derating factors. Conversely, Strategic Reserve 2.0 is less suited for cross-border participation, as it serves as a last-resort instrument, activated only under conditions of extreme system stress, typically when cross-border capacity is either fully utilised or unavailable, and all market-based solutions have been exhausted. In the case of market-wide CRMs, cross-border participation should always be accommodated for.

Finally, the report advocates regulatory harmonisation across the Nordic markets. Recommendations include aligning methodologies for defining the VoLL and reliability standards for each country and promoting cooperation on shared procurement platforms. Such harmonisation is expected to enhance efficiency, reduce operational costs, and minimise fragmented regulatory approaches across the Nordic region.

8.2 Different solutions for different needs

This report does not recommend a single mechanism. Instead, it aims to create a toolbox of the most appropriate mechanisms for different future scenarios, considering the Nordic context.

Key questions to consider are: What are the credible drivers of future scarcity? What challenges do they present, and which types of resources are best suited to address them? How can a mechanism be defined which allows the relevant resources to compete effectively against each other?

The optimal solution for the Nordic region depends on the outcomes of adequacy and flexibility needs assessments, as well as political objectives. Since conducting such assessments falls outside the scope of this study, the recommendations encompass multiple future scenarios, including both likely and less probable ones. While the recommendation provides an indication of the frequency of events and the likelihood that combinations of events could lead to scarcity in the Nordic region, this is based solely on reports available at the time of writing (see Chapter 2.5.1) and is intended as a starting point for evaluating the suitability of different mechanisms. A robust needs assessment is required to determine both frequency and likelihood with greater accuracy.

Exhibit 8.1 presents the recommendations in a tabular format. Based on the preliminary frequency and likelihood of scarcity-related challenges, it provides an indication of the suitability of market-wide versus targeted mechanisms. The table then offers a direct recommendation for one of the shortlisted mechanisms. While the recommendations offer some reasoning in the table, a comprehensive understanding requires a thorough review of the underlying assessment provided in this report.

Exhibit 8.1 – Recommendations based on different future scenarios

Different events give rise to distinct challenges, each requiring a tailored solution.

#	Event	Frequency of event*	Likelihood of causing a scarcity event in the Nordic region within the next 10 years with energy-only market**	Market wide CRM	Targeted mechanism	Reasoning	Preferred option based on assessment	Reasoning
1	**Low intermittent RES output (within-day fluctuations)**	Frequent ■■■■	Highly unlikely ■□□□	Not preferred ↓	Not preferred ↓	These events are already priced into the Nordic energy market. No need for additional intervention.	n/a	n/a
2	**Dunkelflaute (longer periods without intermittent RES output)**	Infrequent ■■■□	Highly unlikely ■□□□	Not preferred ↓	Not preferred ↓	Intermittent RES variability is a fundamental characteristic of the market. Existing price signals should naturally incentivise flexibility, and the current capacity in the Nordics is sufficient to meet demand under normal operating conditions.	n/a	n/a
3	**Cold winter**	Infrequent ■■■□	Highly unlikely ■□□□	Not preferred ↓	Not preferred ↓	Cold winters are a predictable challenge, and existing markets should generate adequate long-term investment signals. Price spikes can be effectively managed through forward markets and hedging strategies, ensuring resilience without the need for additional interventions.	n/a	n/a
4	**Dry years**	Infrequent ■■■□	Highly unlikely ■□□□	Not preferred ↓	Not preferred ↓	Dry years affect hydropower availability but can be mitigated with; existing hydropower planning (using water values) adjusting this naturally; market-based storage solutions (e.g. pumped storage and increased reservoir capacity) and sufficient interconnection to the continent.	n/a	n/a

5	**Large supply outage**	Rare	Highly unlikely	Not preferred ↓	Not preferred ↓	Large supply outages are rare and are typically managed through reserve markets rather than capacity mechanisms. If necessary, providing strong market signals that the procurement of mFRR and aFRR CM volumes will increase years in advance can help incentivise new investments, reducing the need for additional interventions.	n/a	n/a
6	**Inter-connection outage**	Rare	Highly unlikely	Not preferred ↓	Not preferred ↓	As with large supply outages, existing reserve market should address these concerns.	n/a	n/a
7	**Dunkelflaute** **Cold winter**	Rare	Unlikely	Possibly beneficial ↓	Preferred ↑	Continued efforts to improve the energy-only market in the Nordics should be sufficient to prevent this from leading to a scarcity event. However, if assessments indicate that this could become a concern, a market-wide CRM may offer some support but might not be the most cost-efficient solution. Targeted support could be a more effective approach for addressing specific resource adequacy challenges.	**Dispatchable Flexible Reserves**	Encourages new investment in assets that provide within-day and multi-day flexibility, as well as seasonal reliability. Capacity is partly ringfenced from the market to prevent crowding-out-effect, and activated only at critically high prices, indicating a potential capacity shortfall. Within-day flexibility is achieved by triggering assets in the intraday market (eligibility requirements must be adjusted accordingly). Activation in the market makes operability more efficient, avoinding need for dispatch decisions by TSOs.
8	**Large supply outage** **Low intermittent** **RES output (within-day fluctuations)**	Rare	Unlikely	Possibly beneficial ↓	Preferred ↑	Continued efforts to improve the energy-only market in the Nordics should be sufficient to prevent scarcity events. However, if assessments indicate that this could become a recurring issue, a market-wide CRM may provide some support but might not be the most cost-efficient solution. Targeted support could be a more effective approach for addressing specific ressource adequacy challenges.	**Dispatchable Flexible Reserves**	Encourages new investment in assets that provide within-day and multi-day flexibility, as well as seasonal reliability. Capacity is partly ringfenced from the market to prevent crowding-out-effect, and activated only at critically high prices, indicating a potential capacity shortfall. Within-day flexibility is achieved by triggering assets in the intraday market (eligibility requirements must be adjusted accordingly). Activation in the market makes operability more efficient, avoinding need for dispatch decisions by TSOs.

9	**Inter-connection outage(s)** **Low intermittent RES output (within-day fluctuations)**	Rare	Moderate (Denmark)	Possibly beneficial	Preferred	A market-wide CRM could be beneficial if implemented optimally, but targeted mechanism may offer greater efficiency. In particular, a targeted mechanism could be more effective in addressing specific weaknesses, especially in Denmark, which relies heavily on interconnections with other countries.	**FFR availability obligation**	Secure sufficient available capacity in the mFRR Energy Activation Market (EAM) to mitigate flexibility shortfalls caused by outages of other suppliers of flexibility or failures on interconnection towards neighbouring markets that provide flexibility. Compliment FRR CM as this mechanism target new investments. Regulatory challenges related to reserve markets must be addressed.
10	**Dunkelflaute** **Cold winter** **Dry years**	Very Rare	Moderate	Possibly beneficial	Preferred	Cold and dry years are already priced into the energy market. Periods of dunkelflaute are rare, but when combined with cold winters in dry years, they could create a potential 'missing money problem.' Given the infrequency of such events, a targeted mechanism with ringfenced or partially ringfenced capacity would be the least disruptive solution.	**Dispatchable Flexible Reserves**	Encourages new investment in assets that provide within-day and multi-day flexibility, as well as seasonal reliability. Capacity is partly ringfenced from the market to prevent crowding-out-effect, and activated only at critically high prices, indicating a potential capacity shortfall. Within-day flexibility is achieved by triggering assets in the intraday market (eligibility requirements must be adjusted accordingly). Activation in the market makes operability more efficient, avoinding need for dispatch decisions by TSOs.
11	**Dunkelflaute** **Cold winter** **Inter-connection outage(s) or** **Large supply outage**	Very Rare	Moderate	Not preferred	Preferred	The Nordic system should generally have sufficient capacity. However, large outages, though rare, could cause short-term disruptions and may require additional flexibility. Targeted mechanisms with ringfenced assets are the most effective way to ensure investment in critical capacity without distorting the market or leading to unnecessary costs.	**Dispatchable Flexible Reserves**	Encourages new investment in assets that provide within-day and multi-day flexibility, as well as seasonal reliability. Capacity is partly ringfenced from the market to prevent crowding-out-effect, and activated only at critically high prices, indicating a potential capacity shortfall. Within-day flexibility is achieved by triggering assets in the intraday market (eligibility requirements must be adjusted accordingly). Activation in the market makes operability more efficient, avoinding need for dispatch decisions by TSOs.

12	**Dunkelflaute** **Cold winter** **Inter-connection outage(s) or** **Large supply outage** **Dry years**	Very Rare ■■■■	Likely ■■■■	Not suitable ↓	Preferred ↑	To safeguard against these rare events, market-wide mechanisms are not suitable, as they increase overall capacity, which is unnecessary in most years and therefore highly costly. Instead, targeted mechanisms for ringfenced capacity or flexibility are more effective, ensuring investment in specific critical capacity without disrupting the market or leading to excessive costs.	**Strategic reserve 2.0**	Addressing rare but critical adequacy gaps (e.g., extreme weather, unexpected outages). A certain amount of generation or demand-side capacity is kept outside the market and activated only when needed. Ensures additional capacity is available during multi-day or seasonal shortages. Does not provide real-time or within-day flexibility unless combined with other products. Within-day flexibility is possible to achieve with warming contract.

Notes:
*Anticipated frequency of the event combinations. Please note that it is intended for illustrative purposes only, and no detailed analysis has been performed to forecast it in this report.
**This is an indication based on available reports at the time of writing.
Source: AFRY.

The above analysis offers guidance on selecting the most appropriate design for the Nordic region under varying system conditions. It is important to acknowledge that the assessment is based on a number of assumptions regarding scarcity events and their treatment within an energy-only market framework. These assumptions are intended to illustrate likely outcomes; however, no detailed forecasting analysis has been conducted within the scope of this report.

The following sections will outline further recommendations, focusing on cross-border participation and the second order building blocks.

8.3 Cross-border participation

Cross-border participation, while beneficial for minimising global market distortion and potentially improving cost efficiency, can be challenging in many cases. Its suitability depends on the specific mechanism in question. The following section assesses the feasibility of cross-border participation, mainly focusing on the recommended designs in Exhibit 8.1. See Chapter 7.7.1 for more details on cross-border participation.

8.3.1 Targeted mechanisms

Strategic reserve 2.0 services are rarely activated, and when they are, it is typically in response to events such as interconnector failures or periods in which imports are maximised and network capacity between zones is constrained by thermal limits. Since thermal grid constraints may prevent the reserved assets from delivering their response to where it is needed, there is a risk that they will not effectively address scarcity issues. In terms of impact to and from neighbouring markets, their infrequent activation results in minimal market distortion, thereby avoiding negative impacts which would normally imply need for cross-border participation. There may be exceptions.

Conclusion: While enabling cross-border participation in Strategic Reserve 2.0 could enhance global welfare, the risks to domestic security of supply outweigh these benefits. Therefore, strategic reserves are not generally considered suitable for cross-border participation.

FRR availability obligation is considered a suitable solution for addressing real-time challenges, specifically balancing close to real-time. This recommendation is based on the assumption that balancing issues in the Nordic region will primarily occur in situations where available transmission capacity is constrained, for example, during interconnector outages. The key objective of the mechanism is therefore to attract FRR resources locally, ensuring availability in the specific areas where support is needed. As such, assets located in neighbouring areas do not fulfil the eligibility criteria.

It is important to note that awarded assets will bid into their local Energy Activation Markets (EAM), which is expected to be coupled with most of Europe in the near future through the MARI (for mFRR) and PICASSO (for aFRR) platforms. This means that local FRR capacity decisions may have direct cross-border implications for all countries participating in these European markets.

Conclusion: Not suitable for cross-border participation.

Dispatchable flexible reserve, like strategic reserve 2.0, is rarely activated and is unlikely to cause significant market distortion in neighbouring markets. Therefore, the main incentives for enabling cross-border participation would be to enhance overall welfare and reduce operational costs for each country. However, this must be balanced against the risk that these assets may be "out of reach" when needed due to insufficient cross-zonal transmission capacity.

The case for cross-border participation is stronger if multiple countries have a need for and implement this mechanism. In such cases, the likelihood of transmission constraints during scarcity events should be accounted for by applying appropriate derating factors.

Conclusion: Suitable for cross-border participation between markets that implement this mechanism.

Market-wide mechanisms should facilitate cross-border participation. However, it is crucial to properly account for limitations in the cross-zonal transmission grid.

Conclusions: Suitable for cross-border participation.

8.4 Other harmonisation initiatives

Harmonising markets, rules, and platforms across Europe, especially in the Nordic region, is not new. While often challenging, such efforts typically succeed in making markets more efficient in the end. Addressing key issues early prevents complications later when differing rules and systems become entrenched.

Examples like the implementation of SDAC, SIDC, and the integration of European aFRR and mFRR EAM (PICASSO and MARI) show that these projects are lengthy, costly, and prone to delays. This is expected when multiple stakeholders with varying challenges and motivations must align. Converging different system needs into a unified framework requires compromises, often leading to suboptimal solutions. It is far easier to agree on a new design before commitments are made than to renegotiate once systems are established, when change becomes difficult and contentious. At the same time, it may be prudent to strike a balance by initially launching a minimum viable product, deferring more complex features and refinements to later stages. This can help avoid protracted debates that risk stalling progress entirely.

To minimise future challenges, early consensus among Nordic decision-makers is recommended on the following:

- **Needs assessment:** Align adequacy and flexibility assessments across the Nordic countries.
- **VoLL:** Common methodology for defining VoLL, as recommended by ACER in their 'Security of supply 2024' report on a European level.
- **Regulatory harmonisation:** Where applicable, adopt a common approach to CRM or NFFSS rules.
- **Platform cooperation:** For markets introducing new mechanisms, explore shared systems for procurement. Even if mechanisms differ, certain features can be aligned. Using a common system provider can help save costs.

Ultimately, it comes down to timing. Early alignment prevents issues in the future.

8.5 Second order building blocks

Once policymakers have completed a needs assessment and determined that a capacity or flexibility mechanism is required to handle a given event (see Chapter 2.5.2), they must decide on the appropriate type of mechanism (see Chapter 5) considering the fundamental design choices (see Chapter 4.2). Beyond these initial decisions, second order design choices must be addressed to ensure the mechanism is effective and well-aligned with system needs. These second-order building blocks can generally be adapted to fit any of the designs. The following section discusses the second order building blocks, focusing on the recommended design in Exhibit 8.1.

Contract type and duration

Strategic reserve 2.0 may allow shorter contracts, such as annual or seasonal, if attracting existing assets to prolong their lifetime is the ambition. Similarly for refurbishments, such as having CHP plants to be able to switch to biofuels instead of heat pumps to deliver heat. DSR may accept or even prefer shorter contracts (although this cannot be assumed universally). The business case for bidding into such mechanisms relies on any investment and operating cost being fully financed by the mechanism, since it cannot participate in the market or get revenue from any other sources.

Ringfenced or restricted solutions aimed at new investments, such as dispatchable flexible reserve, will require long contracts. The business case for bidding into these mechanisms relies on the investment cost to be fully financed by the mechanism, since it cannot participate in the market or get revenue from any other places.

FRR availability obligations would also typically require longer contracts as might require new investments, but refurbishments and (some) DSR could potentially be open to shorter contracts.

Market-wide mechanisms should accommodate different types of capacity providers through varied contract durations. This can help to ensure a balanced mix of resources, enhancing overall system reliability and resilience, while allowing resources to offer a range of services at different times, enabling revenue-stacking (and cost-sharing).

The Nordic region would benefit from a form of shaped (time-specific) contract, as conditions leading to scarcity events are most likely to occur during winter. Both market-wide and targeted mechanisms could benefit from using shaped contracts to reduce costs. However, the needs assessment should adequately investigate this to confirm that scarcity events are indeed limited to winter periods.

Duration of need

The duration of need should be established through a comprehensive needs assessment. Recent studies indicate an evolving diversity in system requirements, highlighting the necessity for capacity capable of rapid response as well as sustained operation over extended periods. AFRY's modelling of the GB electricity system underscores this trend, stating: "Critical stress events move from typically a few hours to multiple days in duration. The GB system moves from one in which critical stress events are a few hours in duration, driven by high demand coinciding with plant failure, to one in which critical stress events are due to weather events that last multiple days in duration"[40]. Similar conclusions were presented in a joint report by Wärtsilä and AFRY on Finland, noting: "A difficult weather year in the Finnish context means a year with days to weeks of simultaneous high demand and low output from wind power."[41]

40. AFRY Management Consulting (2023), Long-Term Capacity Adequacy Assessment – National Grid ESO Study, published 9 January 2023. Available at: https://bid3.afry.com/download/18.265bb48a1968504d618365d5/1746210114097/Resource%20adequacy%20in%20the%202030s%20Final_0.pdf
41. Wärtsilä & AFRY Management Consulting (2024), How Firm and Flexible Capacity Supports Finland to Become a Green Superpower – Capacity Market Options for Finland, April 2024. Available at: https://www.wartsila.com/docs/default-source/local-files/finland/wartsila-afry-report_finland-to-become-a-green-superpower.pdf?sfvrsn=62b61f43_3

Market time unit (MTU)

The design should target shorter MTUs to facilitate participation by flexible technologies, ideally non-fossil assets, such as BESS and DSR, which cannot respond for extended periods. Relying solely on technologies capable of continuous energy delivery throughout the entire period would restrict participation and may result in higher costs compared to the alternative.

Procurement mechanism

The choice of procurement mechanism depends on other design considerations. More frequent and complex procurements, attracting a range of technologies and providers, suggest that auctions represent the optimal approach. Conversely, one-off or infrequent procurements might be better addressed through tenders.

Cooperation and harmonisation across Nordic borders would likely be most effectively managed through auctions, where an auction optimisation algorithm can ensure reliable and consistent outcomes.

Lead-time and frequency of procurements

It is critical to allow sufficient lead-time to enable new-build projects, while balancing this against the urgency for rapid deployment. Shorter lead-times typically favour assets that can be deployed quickly, potentially excluding technologies that may offer greater competitiveness over the long term. Reviewing typical construction times (see Chapter 2.7.2) can help identify the types of assets the mechanism should target.

Short-term flexibility requirements are best addressed through procurement processes characterised by shorter lead-times and smaller MTUs, in order to maximise market participation. In contrast, long-term flexibility needs are more effectively met through mechanisms that offer extended lead-times and longer contract durations, reflecting the higher upfront investment typically associated with such assets. A balanced procurement strategy that combines both short- and long-term measures can help ensure immediate system stability while also supporting sustained investment in flexible resources.

Nature of penalty

A design that involves the application of an administered penalty in combination with non-payment in the event of non-availability is recommended. This applies to all the shortlisted designs.

Annex A: Design objectives and constraints

A.1 Primary design objectives

<table>
<thead>
<tr><th>Objective</th><th>Description</th><th>Assessment criteria</th><th>Description</th><th>Evaluation</th></tr>
</thead>
<tbody>
<tr>
<td rowspan="3">Cost efficient provision</td>
<td rowspan="3">Respecting existing investments: Ensure that market design do not undermine or devalue prior investments, providing continuity and stability for existing asset owners. This include prevent undue distortions of existing electricity markets.

Participation barriers: Enable a wide range of market participants, including generators, storage providers, and demand-side resources, to freely participate on equal terms.

Minimising overall system costs: Ensure the market delivers capacity at the lowest possible cost to consumers.

Avoid over-procurement: Only procure the capacity needed to meet reliability standards, avoiding excess capacity.

Market equilibrium: Ensure that the costs of maintaining capacity adequacy align with the societal value of having a reliable energy supply (value of lost load (VoLL)).

Efficient use of resources: Maximise the use of available generation, storage, and demand response resources - in the Nordics and nationally.</td>
<td>Low degree of distortion</td>
<td>The solution has a neutral or positive impact to the market/industry (producers and consumers) business models, with low impact on prices - respecting existing investments.</td>
<td>Low degree
■□□□

High degree
■■■■</td>
</tr>
<tr>
<td>Market efficiency and inclusivity</td>
<td>Ensure the market delivers capacity at the lowest possible cost to consumers by fostering liquidity, encouraging innovation, and incentivising the adoption of new technologies and efficient solutions.</td>
<td>High effectiveness
■■■■
Low effectiveness
■□□□</td>
</tr>
<tr>
<td>Resource efficiency</td>
<td>Promote efficient use of resources. Maximise the use of procured generation, storage, and DSR resources - in the Nordics and Nationally</td>
<td>High efficiency
■■■■
Low efficiency
■□□□</td>
</tr>
</tbody>
</table>

Maintain system security	**Adequate capacity procurement:** Ensure sufficient capacity is procured to meet peak demand and avoid shortages. **Reliability standards compliance**: Meet established reliability standards to ensure continuous supply, especially during critical periods. **System flexibility and reliability:** Encourage reliable flexible resources that can ramp up or down to balance supply and demand fluctuations.	**Effectiveness**	Is effective in **solving the problem**, i.e. ensuring security of supply in a robust and reliable way, relative to other options. Does *not* consider cost or complexity of solving it.	High effectiveness Low effectiveness
Support a zero-carbon system	**Encourage renewable integration**: Prioritise capacity mechanisms that facilitate the integration of wind, solar, and other renewable energy sources. **Promote low-carbon technologies:** Support investments in low or zero-carbon technologies such as battery storage, hydrogen, and carbon capture. **Incentivise flexibility**: Encourage flexible resources, such as demand-side response and storage, to support the variability of renewable energy.	**Non-fossil**	The solution exclusively promotes non-fossil options or allows support for both non-fossil and other energy sources	Non-fossil Incl. fossil

A.2 Secondary design objectives

Objective	Description	Assessment criteria	Description	Evaluation
Transparent	**Visibility of TSO needs, bids & results:** Ideally open access to information, incl. historical data (results), TSO needs, bids, and commitments. **Visibility of decision-making:** Ensure that the decision-making processes, especially around auctions and capacity allocation, are transparent and well-documented.	**Transparency**	The solution promotes transparency	High transparency Low transparency
Investable	**Predictable revenue streams**: Ensure that market participants can expect consistent and predictable returns over the long term. **Support for new technologies**: Encourage investment in innovative and emerging technologies (e.g., renewables, storage) by providing a level playing field or specific incentives.	**Investor confidence**	**Degree of investor confidence,** supporting efficient future investments. Provides sufficient incentives for targeted asset groups. Exposes industry to appropriate risks, i.e. risks they can manage	High confidence Low confidence

Practical	**Ease of Implementation:** Ensure the market design is straightforward to implement, with minimal complexity for regulators, operators, and participants. **Simplicity in Market Participation**: Make it easy for generators, demand-side resources, and other participants to engage in the market without excessive administrative burden. **Administrative Efficiency**: Minimise the time and costs required to administer the market, including auction processes and compliance monitoring.	**Ease of implementation**	Is not complex to implement and can be delivered in an appropriate timeframe. The evaluation approach considers following factors: technical, political, regulatory complexities and time to market.	Low effort High effort
		Operational simplicity	Assesses operational simplicity for market participants as well as operators	Simple Complex
Enduring	**Long-Term Market Certainty:** Provide clarity on future market conditions and regulations to foster investor confidence in long-term investments. **Adaptability to Future Needs:** Design the market to be flexible enough to accommodate evolving technologies, market conditions, and policy goals without frequent overhauls.			
Limit negative cross-border impact	**Minimise distortion on neighbouring markets:** Minimise unintended negative consequences on neighbouring markets. Given the interconnected nature of electricity markets, poorly designed support mechanisms can distort price signals, create inefficiencies, or lead to unfair cost burdens on neighbouring countries. **Fair welfare distribution:** Support mechanisms should not disproportionately benefit one country at the expense of another	**Cross-border impact**	Evaluate the impact on neighbouring markets, both with and without cross-border participation	Qualitative evaluation

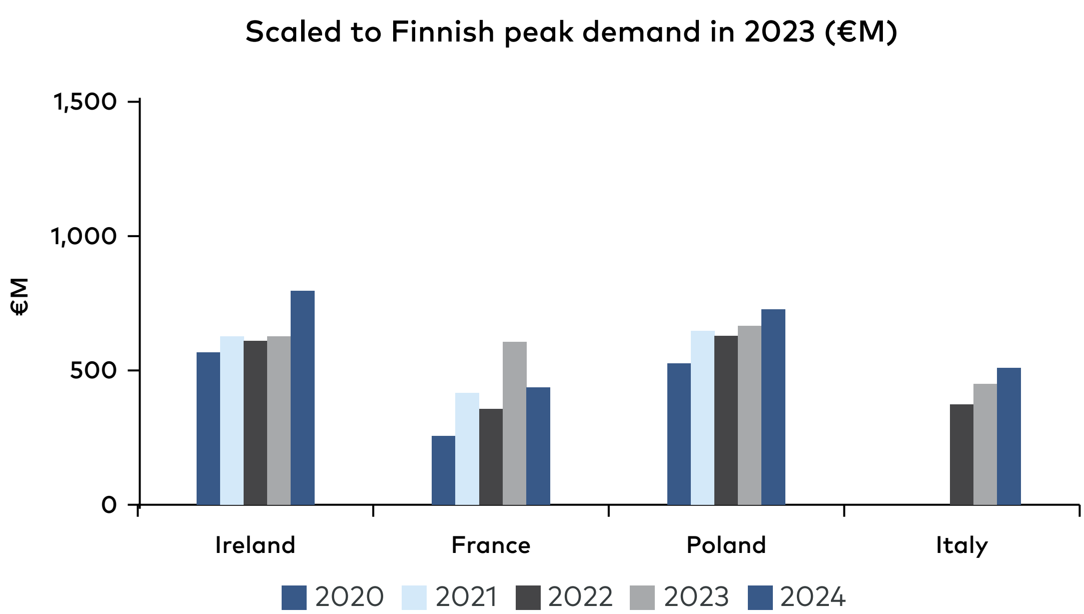
A.3 Design constraints

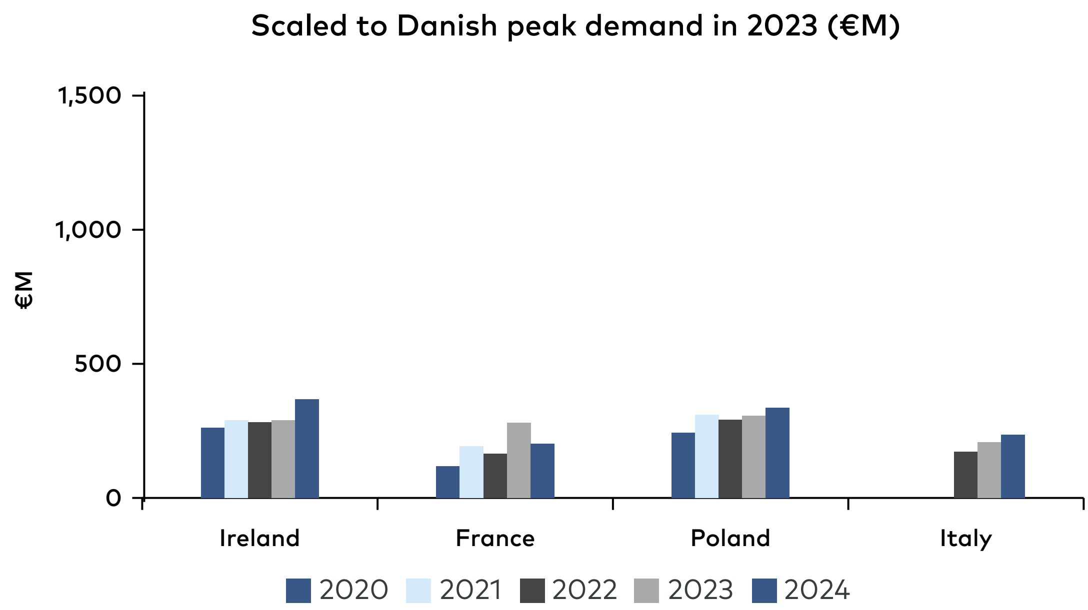
Constraint	Description
Market based	The schemes should be implemented in a way that is **consistent with general market principles**, promoting competition and efficiency within the electricity market.
Targeting new investments	The non-fossil flexibility support scheme should **limit support to new investments**. This include new capacity investments and upgrades to existing facilities or solutions.
Non-fossil	The non-fossil flexibility support scheme specifically target flexibility resources that **do not rely on fossil fuels**, including flexible resources such as: Renewable dispatchable generation; energy storage and demand response.
EU compliant	**Compliance with EU energy regulations:** The market design must align with existing EU regulations, such as the electricity regulation, to ensure that it will be approved by the European commission.

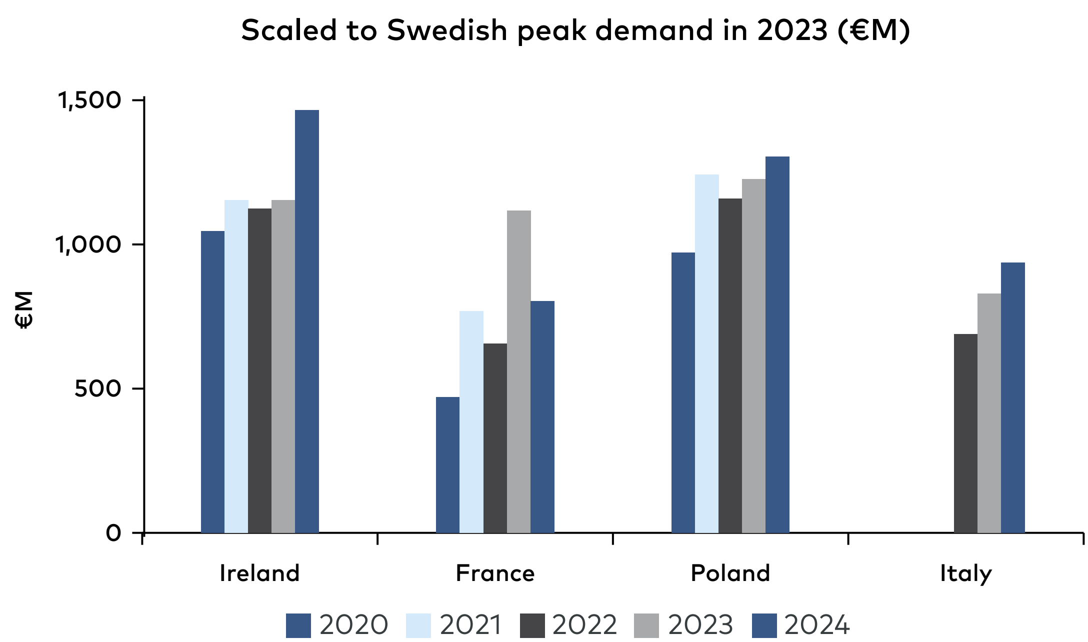
Annex B: Costs of market-wide capacity mechanisms

Exhibit 8.2 – Costs of market-wide capacity mechanisms, scaled for peak demand in each Nordic country in 2023 (million euros)

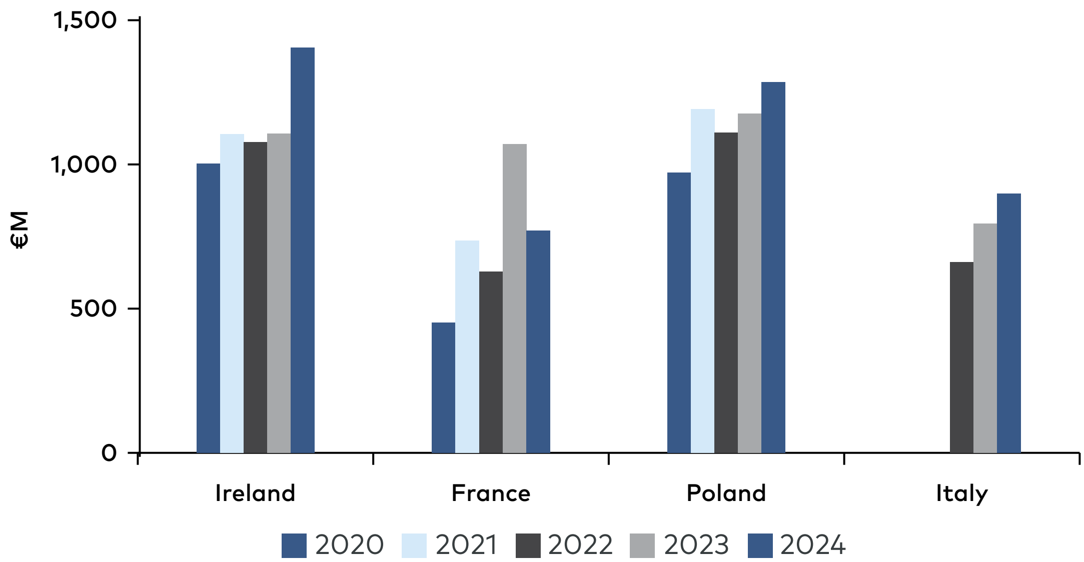
Peak demand (GW), 2023:
Denmark 6,1 / Sweden 24,3 / Finland 13,2 / Norway 23,3




Scaled to Danish peak demand in 2023 (€M)
1,500
1,000
500
0
€M
Ireland
France
Poland
Italy
2020
2021
2022
2023
2024


Scaled to Swedish peak demand in 2023 (€M)
1,500
1,000
500
0
€M
Ireland
France
Poland
Italy
2020
2021
2022
2023
2024

Scaled to Norwegian peak demand in 2023 (€M)



Note: Based on data from 2020-2024
Source: ACER.

Annex C: Technologies' functionality and flexibility potential

Dispatchable generation

Dispatchable generation consists of power plants that can be controlled and adjusted in real-time to match electricity demand. These sources include hydropower, bioenergy, gas-fired power plants, and to some degree nuclear power.

Contribution to system security:

- Real-time: Rapidly ramps up or down to stabilise grid frequency and voltage.
- Within-day: Supports peak load management by adjusting output during morning and evening demand spikes.
- Multi-day: Provides backup during periods of low renewable generation, such as dunkelflaute.
- Seasonal: Reservoir hydropower and power plants using storable fuels can retain energy for months, making them crucial for securing winter supply. This is particularly important for hydropower in the Nordic region, where inflows to reservoirs are minimal during winter. To ensure a stable energy supply, stored water (representing stored energy) must last throughout the season until snowmelt fills reservoirs in spring.

Intermittent renewable energy sources (RES)

Intermittent RES, such as onshore and offshore wind and solar PV, generate electricity based on natural conditions, resulting in variable and less predictable output. As a result, they are not considered technologies suited for ensuring system stability but rather a key driver of instability. However, they are an integral part of the green transition. In a market-wide CRM, these assets can also receive capacity payments, though with a derating factor to account for their limited reliability in delivering capacity during scarcity events.

Contribution to system security:

- Real-time: Limited direct contribution, but smart forecasting and curtailment strategies help mitigate short-term imbalances.
- Within-day: Solar PV provides peak generation during daylight hours, while wind generation often complements night-time demand.
- Multi-day: Wind and solar can reduce reliance on fossil-based generation but require backup when generation is low.
- Seasonal: Offshore wind aligns well with winter demand peaks, while solar PV contributes more significantly in summer, highlighting the need for seasonal storage.

Short-duration storage

Short-duration storage solutions, such as lithium-ion batteries, supercapacitors, and flywheels, store energy for seconds to a few hours, enhancing grid flexibility. The latter two has low energy density but can deliver bursts of power within milliseconds. They are typically used to provide real-time frequency response only.

Contribution to system security:

- Real-time: Provides instantaneous frequency response and grid stabilisation.
- Within-day: Manages fluctuations by storing excess solar or wind power and discharging during peak demand.
- Multi-day & seasonal: Limited contribution due to storage constraints; primarily used for intra-day balancing rather than prolonged shortages.

Medium-to long-duration storage

Medium- to long-duration storage covers technologies like flow batteries and sodium-sulphur batteries, which store energy for 4–24 hours. This category represents immature technologies.

Contribution to system security:

- Real-time: Not optimised for fast response but can support grid balancing through controlled discharge.
- Within-day: Essential for shifting excess midday solar power to meet evening demand.
- Multi-day: Extends system resilience by covering short renewable droughts.
- Seasonal: Limited seasonal impact due to moderate storage capacity.

Long-duration and seasonal storage

These technologies, including pumped hydro storage (PHS), hydrogen storage, iron-air batteries, and thermal energy storage (TES), can provide multi-day and seasonal energy reserves.

Contribution to system security:

- Real-time: Some options, like PHS, provide fast ramping capability.
- Within-day: Can discharge stored energy over extended periods, improving grid stability.
- Multi-day: Iron-air and zinc-air batteries can sustain output for days, bridging renewable shortfalls.
- Seasonal: Hydrogen storage and TES in district heating networks enable long-term energy shifting, addressing winter shortages.

Demand-side response (DSR)

DSR refers to mechanisms that adjust electricity consumption to match grid conditions, with participation from industrial, commercial, and residential consumers. DSR has great potential and could solve most of the challenges caused by the green transition. However, attracting demand-side to respond to price signals has proven difficult. While this is a challenge that must be addressed to fully utilise DSR flexibility, the below describes its potential.

Contribution to system security:

- Real-time: Supports frequency control by reducing or shifting demand instantly.
- Within-day: Helps smooth peaks by incentivising off-peak electricity use.
- Multi-day: Industrial demand flexibility (e.g., electrolysis, cold storage) can help manage prolonged supply shortages.
- Seasonal: Reduces strain on the grid in winter by shifting heating and industrial loads.

DSR with storage

A combination of demand flexibility and energy storage, such as electric vehicles with vehicle-to-grid (V2G) capability, industrial facilities with on-site batteries, and electrified district heating with TES or alternative fuels.

Contribution to system security:

- Real-time: EVs can provide rapid frequency response via bidirectional charging.
- Within-day: Enhances peak shaving by dynamically adjusting demand.
- Multi-day: Batteries within DSR programmes can store and discharge power when required.
- Seasonal: District heating with TES ensures reliable winter heating, reducing electricity demand.

Grid infrastructure

Grid infrastructure includes HVDC interconnectors, smart grids, dynamic line rating (DLR), and virtual power plants (VPPs), enabling efficient energy transmission and distribution.

Contribution to system security:

- Real-time: Smart grids improve system monitoring and response times, reducing failures.
- Within-day: HVDC interconnectors allow cross-border electricity exchange, helping meet peak demand.
- Multi-day: Reinforced transmission networks can import/export energy during renewable shortfalls.
- Seasonal: Enhances grid resilience by connecting diverse renewable resources across regions.

About this publication

Toolbox for a Secure Energy Supply – Capacity Mechanisms and Non-Fossil Flexibility Support Schemes

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